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Forthcoming Events.

DECEMBER 9.

Burnley Section of the Lancashire Branch:—Ordinary meeting at Burnley. "Foundry Work and the Drawing Office." Paper by A. Sutcliffe.

DECEMBER 11.

Institute of British Foundrymen (London Branch) and Institute of Metals (London Section):—Joint meeting in London. "Present Problems and Development in Engineering Bronze Foundry Practice, Paper by F. W. Rowe, B.Sc.

DECEMBER 12.

Institute of Metals (Swansea Local Section):—Discussion at Swansea on "The Design of Furnaces for Annealing and Heat Treatment."

DECEMBER 13.

Institute of British Foundrymen (Newcastle-on-Tyne Branch):—Ordinary meeting at Newcastle. Paper by J. G. Pearce.

Institute of British Foundrymen (Wales and Monmouth Branch):—Ordinary meeting at Newport. "Testing Castings," Paper by F. C. Edwards.

Swansea Technical College Metallurgical Society:—General meeting at Swansea. "Estimation of Tin in White Metals and Steel," Paper by Capt. J. R. Green, B.Sc., A.I.C.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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The Metallurgical Provision of Scrap.

The large scrap dealer more closely resembles a manufacturer than he does an ordinary merchant, because his business involves the provision of scrap in such a form that it will readily enter an ordinary furnace door or the pan of a charging machine. Additionally, they sometimes bundle scrap of a light and flimsy character to facilitate subsequent handling. Should they do more? We have previously suggested that they should make a serious endeavour to ascertain the chemical composition of what they buy and pass this information on to the purchaser. Now the suggestion is being made to the trade that the scrap metal merchant should install furnaces and supply scrap in ingot form. For a limited trade in certain metals this is already customary, but, generally speaking, its further extension is unwise on the following grounds:—Primarily, the larger the ingot the less the surface area exposed, and the longer the time taken to melt; secondly, the provision of very small ingots is a costly process. Then if the ingots were metallurgically satisfactory there would be a temptation for the merchant to compete with his customers. An examination of each process will reveal the true position. The crucible steel manufacturer would never envisage the use of scrap in ingot form unless quite small, when the price would be prohibitive. For the large open-hearth furnaces no advantage can be shown, because it would never eliminate chemical control of the molten bath. The Bessemer process, *per se*, uses but a small quantity of scrap at irregular intervals, and insists that it presents a larger surface area than is exhibited by ingots. The electric steel furnace has no interest in using ingots.

Of outstanding interest to foundrymen is whether the metal merchant should pass his cast-iron scrap through a melting furnace and provide the foundry with a material of known composition. Obviously, it would aid the foundry manager better to mix to analysis. But can he perform this function better and more economically than the foundries themselves? We suggest he cannot, because a hot cupola is at very regular intervals available to the foundries for the provision of "known" scrap; that there would be a maximum transport cost on the merchant's ingot- (or pig-) form scrap, and that after some experience the foundry can blend various scraps to produce the most economical and satisfactory composition for re-melting—a function which could not be expected from a merchant. Finally, foundries could only expect merchants to supply them with either (*a*) scrap of specially suitable composition, or (*b*) a stock list of quantities of classified compositions. The first function is already being met by firms highly versed in the requirements of foundries, whilst the second would probably leave much stock on the hands of the merchants, and might ruin large quantities of perfectly good scrap by rendering it almost useless for several sections of large buyers.

The remelting of metals is seldom a mechanical process, and if any metal merchant decides to embark upon such a venture then he must employ a highly skilled metallurgist, or much trouble is likely to ensue.

Scrap merchants will best serve the metallurgical industries by an intelligent sorting of the various scrap which comes into their hands, and by rendering it by mechanical means into a suitable mechanical condition and size for charging into industrial furnaces, thus leaving any metallurgical preparation in the hands of the consumers or firms specially qualified to perform that function.

XUM

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Filtration of Cast Iron.

To the Editor of *The Foundry Trade Journal.*

SIR,—I have read with considerable interest Signor Ing. Cesare Brunelli's article in THE FOUNDRY TRADE JOURNAL, October 2, issue No. 424, on the "Filtration of Cast Iron." He rightly emphasises the importance of selecting the best method to run a casting and the value of strainer cores. This is a subject that has been discussed generally during the past few years, and I believe its importance is appreciated by foundrymen throughout the world.

Signor Brunelli's explanation of the cause of cavities and spongy places in iron castings of any dimensions or of varying sections, however, is certainly unique, and calls for some criticism. He contends that "when metal is run into a mould it causes rarefaction of the interior of the mould, and facilitates the penetration of new air, and by so doing establishes a continuous circulation that only ceases when the mould is filled." Thus, in a mould of 20 cubic inches fed by a runner having one large riser 15 mm. diameter, the air was renewed 14 times. *It would be of interest to learn how he arrived at this figure.* He then explains that the defect under a riser and at the change of section in a casting is due to the direct incorporation of the atmospheric air. He then states, "Any casting of cylindrical form, no matter how massive, turns out quite solid, even when cast horizontally, if poured with filtered cast iron and if protected against the action of the atmosphere." Also, "before the discovery of the combined action of the filtration and elimination of air, it was not possible to cast such castings horizontally owing to the agglomeration of impurities which took place, and also to the sinking of the metal along the top of the cylinder, set up by the large number of air bubbles present, regarded as a spirit level."

Finally, he adds that the application of the "filtration process," which gives unhoped-for results, requires the studied observance of two principles—filtering the metal and isolating the mould from the atmosphere.

Would that it were possible to eliminate the metallurgical fundamentals from the foundry so easily! A millennium for the metallurgist, but Nemesis for the moulder.

Signor Brunelli states that he can produce any class of casting sound commercially without consideration of metallurgical principles, and that "all bad castings must be attributed to incorrect venting of cores and not using filter gates."

Fortunately for the moulder, this is not so. The metallurgy of cast iron plays just as important a part in the production of sound castings as a knowledge of moulding methods and the principle of running castings.

Brunelli's first contention that "segregation of phosphorus is not possible because there cannot be a sufficient quantity of phosphorus by volume" is erroneous, as anybody with any knowledge of metallurgy well knows. It will be instructive to Signor Brunelli to learn that phosphorus does not exist as such in cast iron, but that it forms a phosphide eutectic, and that in a 1 per cent. phosphorus iron no less than 20 per cent. of the whole casting consists of a low-melting point phosphide, which solidifies approximately at 465 deg. F. (260 deg. C.) lower than the main body of the casting.

If Signor Brunelli will examine the internal draws or spongy places of ordinary grey iron castings containing over 0.25 per cent. phosphorus he will have no difficulty in finding phosphide segregations, caused by the liquation of this substance.

The statement that "liquation in ordinary castings is impossible because of simultaneous solidification" also requires correction. Simultaneous solidification conditions are not possible from a metal solidifying through a wide range of temperatures when cast in the ordinary sand mould. Consider this for a moment in its application to the 8-in. diameter cylinder referred to by Signor Brunelli—a casting of very simple form made in a baked-sand mould. The actual time taken for the iron to solidify after filling the mould by means of a ¼-in. jet runner was 125 minutes—two hours five minutes.

Solidification commenced at 2,180 deg. F. (1,190 deg. C.), and finished at 1,715 deg. F. (935 deg. C.). Signor Brunelli will admit that this period of time is such as to permit of selective freezing. It may be argued that an 8-in. section is not common to ordinary castings, and that the time-factor would be negligible.

This, however, is not so. Take, for example, the port of an ordinary locomotive cylinder. Actual time-figures made during solidification were as follows:—Incipient solidification commenced at 1,212 deg. C., and final solidification was complete at 938 deg. C. The total period of time taken to solidify was 19 mins. 10 secs. The phosphorus content of the port of cylinder analysed was as follows:—Main body of cylinder, 0.53; liquation at port, 0.94; and spongy area at port, 0.17 per cent. So much for the time element and phosphorus.

If Signor Brunelli will refer to THE FOUNDRY TRADE JOURNAL, January 3, 1924, page 5, he will find there an exposition on the genesis of structure in steel, cast iron, brass and bronze. There also he will find practical examples dealing with the mechanism of crystallisation of alloys during solidification, showing that when alloys freeze through a range of temperatures solidification is always progressive, the higher melting-point materials first falling out of solution along the axes of the crystal system to which the alloy belongs, giving a skeletal outline of each crystal grain and leaving the low melting-point material to fill the interstices of the skeletal framework thus formed.

Passing from this phase of the subject, I would next refer him to various researches conducted on the volume changes of grey cast iron on solidification, particularly to Professor Turner's research, Rosenberg's experiments ("Stahl und Eisen," 1911, 31, 1408-1413), and also to a Paper in THE FOUNDRY TRADE JOURNAL, February 1, 1923. Signor Brunelli will find that grey cast iron may expand on solidification, or many even contract, and that *this volume change is primarily responsible for the cavities and spongy places to which he refers.*

Such defects must not be attributed to phosphorus, entrapped water vapour or gases from the mould.

Of course, this does not mean that a spongy place or cavity cannot come about from incorrect venting or incorrect running.

If Signor Brunelli will read my Paper more carefully, he will find that no steam could be trapped in the casting to which he refers, for all the moulds used in that research were bone-dry. They were baked for 24 hours at 400 deg. F. (205 deg. C.). Moreover, although the castings were poured with three and five delivery points, they exhibited just as pronounced a defect.

To convince Signor Brunelli of the fallacy of his statement "that all draws in cast iron must be due to steam or entrapped air," he should take an 8-in. cylinder or such a mass of molten iron and retain it in the liquid state for any period of time he considers necessary to remove all mould gases. I would suggest ten minutes. As an alternative, he could melt the iron in the mould, and allow it to solidify without disturbing. He will find the same draw or spongy place in his casting. On further experimenting, he will be convinced that *temperature of pouring, chemical composition of the iron used, rate of cooling, rigidity of mould walls and method of moulding* are just as important factors in the successful production of sound castings as rate of running and disposition of gates.—Yours, etc.,

O. SMALLEY.

American Manganese Steel Company,
Denver, Colorado.

Mr. Hollinworth's Illness.

We are sorry to report that there is still no improvement in Mr. Hollinworth's condition at the time of going to press.

Castings for Diesel Engines.

Important Conference in Glasgow.

The interest taken in problems connected with the production of castings for Diesel engines was shown by the large number of prominent foundrymen and engineers who attended a joint conference held in Glasgow under the auspices of the Institute of British Foundrymen and the Institution of Mechanical Engineers. As is well known, many of the large engineering firms in Glasgow are at present engaged in the construction of Diesel engines of high powers, and demands are being made on iron founders for castings which will prove reliable under higher temperatures and greater stresses than have ever been known hitherto in either steam or internal combustion engines. It was thought therefore that a joint meeting between the Scottish Branches of the two Institutions would serve to bring the foundryman and engineer into closer association and afford a means of discussing the problems associated with the successful production of oil engine castings. The various speakers dealt with different phases of these problems. The discussion was opened by Professor Mellanby, who spoke on "Temperature Stresses and Working Conditions of Oil Engines;" then followed Mr. A. Campion, who dealt with "Characteristics of Cast Iron for Oil Engines;" Mr. James Richardson, B.Sc., spoke on "Oil Engine Design as Affected by Foundry Practice;" and Mr. William Bell, on "Oil Engine Design from a Moulder's Point of View."

Temperature Stresses and Working Conditions in Diesel Engine Cylinders.

By Professor A. L. Mellanby, D.Sc.

When the proposal to have this short group of papers was made, it was thought that it would be of advantage if the first speaker would give some indication of the temperature conditions that existed in Diesel engine cylinders. As the author has had a fairly large experience in temperature measurement in Diesel engines of large and small powers, he proposes to give one or two illustrations which will show, first, how temperature stresses may arise in pistons and cylinders, and, secondly, how cast iron may be expected to behave at elevated temperatures.

It is well known that in the early period of the history of the Diesel engine, cracked liners and pistons occurred very frequently. Experience has shown, to a large extent, how to overcome these troubles, but there is always the fear that, when cylinders are made larger and the power per cylinder increased, such experiences may be repeated. If, however, the designer can have some information as to the conditions under which the engine has to work, he will be in a much stronger position to guard against possible difficulties.

In Fig. 1 will be found information as to the temperature existing in an uncooled Diesel engine piston. This example is not taken from the

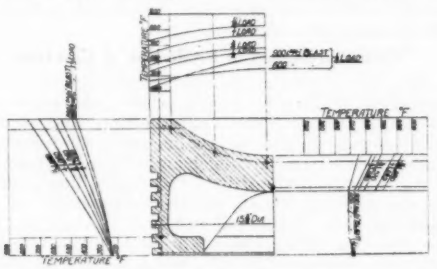


Fig. 1.—Temperature Conditions in a Diesel Engine Piston.

writer's own experimental results, but is from some German tests, and it is given because it represents the most severe conditions he has encountered. In the larger engines where the pistons are water- or oil-cooled, the temperature conditions are much less severe. With the uncooled piston most of the heat has to pass from the centre to the circumference and from there to the cylinder walls, and with such a path for the heat there is a large temperature difference between the centre of the piston and the outer circumference. This naturally sets up very severe temperature stresses which, combined with the loads produced by the high pressure, may result in failure. It has been estimated by Professor Hopkinson that, if the top of the piston were treated as a flat disc, the stresses in a piston 11½ in. dia., when the temperature difference between the centre and circumference was 390 deg. F., would be about 7½ tons per sq. in.

It has been stated that Fig. 1 shows the worst temperature conditions with which the writer is acquainted. This statement requires some qualification. While the maximum temperature is the highest that he has come across, the temperature difference between centre and circumference is relatively small. With a 12-in. cylinder tempera-

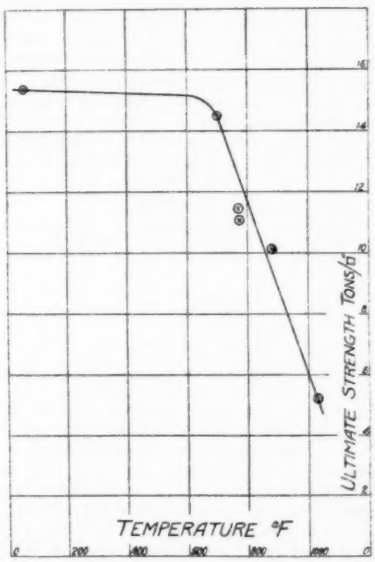


Fig. 2.—Strength of Cast Iron at High Temperatures.

ture differences of 400 deg. F. between the centre and circumference have been observed and under these conditions the stresses set up will be very severe.

With liners the temperature never reaches so high a point as in the piston, and a maximum temperature of, say, 300 deg. F. at the inner surface of the liner has been measured. Here again the temperature difference between the inner and outer surfaces is the source of danger, a point that is now being appreciated by designers. Changes in liner design are constantly taking place and, where temperature and pressure conditions may be severe, the placing of large chunks of metal, which acted as heat reservoirs and set up large stresses, has been abandoned.

Actual Temperatures.

While from the stress point of view temperature difference is of importance, it is equally important that the value of the maximum temperature should be known. The cast iron has to stand the stresses induced by the high pressure and temperature difference, it is repeatedly heated and cooled, and it is subjected to wear. It is therefore necessary to know how cast iron will behave under high temperature conditions.

So far as tensile strength is concerned, Fig. 2 illustrates how this is reduced as the temperature rises. In this diagram the specimens were heated and stressed at the same time. That is to say, the

load was applied during the whole test, which, in some cases, amounted to many hours. In this connection it may be well to issue a warning against accepting test results in which the specimen was left at the high temperature for a short time only, say, half an hour or an hour, and the load then applied till breakage occurred. Such test results will always give too high a value for the tensile strength at the higher temperature. The important point to notice from the figure is the rapid diminution of strength that results from an increasing temperature above 700 deg. F. (370 deg. C.). This diagram represents the performance of both good and bad varieties of cast iron. The strength at low temperature may be either greater or less than the values shown in Fig. 2, but the rapid strength diminution always appears to take place somewhere in the neighbourhood of 700 to 800 deg. F. (370 to 425 deg. C.).

Growth.

There are, however, other points that must be considered when the behaviour of cast iron at high temperature is receiving attention. Experience has shown that cast iron which is subjected to alternate heatings and coolings is liable to undergo changes in volume. This phenomenon is generally classed under the heading of growth, and it is well known that many examples have arisen in practice when engineering details, subjected to alternating high and low temperatures, have so far changed their shape and volume that they have caused considerable trouble. It becomes necessary, therefore, to know with some accuracy to what extent these changes of dimension can take place. Fig. 3 throws some light upon this subject. The curves illustrate the changes in length of a number of specimens, 6 in. × ¾ in. diameter, which have been raised a number of times to a temperature of 977 deg. F.

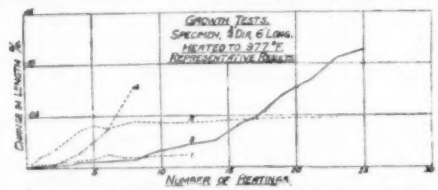


FIG. 3.—GROWTH TESTS ON GREY CAST IRON.

(525 deg. C.), and then allowed to cool slowly. How far the growth properties of different varieties of cast iron can differ when subjected to this treatment is well brought out by the figure. Curve 4 represents the behaviour of a sample which was supplied as an example of good cast iron for steam-engine cylinders. Curve 3 is from a sample of Continental iron which was supplied with the recommendation that it was suitable for Diesel engine pistons. The figure shows that this claim can hardly be upheld. Curve 2, which is, by comparison, quite good, is supplied by an iron which was taken from a Diesel engine liner that had done a large amount of satisfactory service. Curve 1 is from a cast iron that was also put forward as suitable for Diesel engines. So far as resistance to growth is concerned, it would appear to satisfy the claim.

Wear.

There is always the problem of wear to consider, since it is well known that liners have had in some cases to be renewed after a comparatively short life on account of the rapid abrasion by the piston rings. Wear measurements are rather difficult to make in the comparatively short time that is available for a test, but comparisons that have been made by the help of a quite simple abrasion test have shown that the wearing properties of cast iron may differ quite as much as their growth properties. It is, however, of interest to note that resistance to wear may be associated with resistance of growth, and that the iron of Curve 1, Fig. 3, came out equally well when its wearing properties were tested.

The author has thus attempted to give some idea of the nature of the temperatures that are reached in the working parts of a Diesel engine, and to point out that one of the dangers to be guarded against is the setting up of big temperature differences across any section of metal. Some indication has also been given of the way in which the tensile strength and the growth of cast iron is governed by high- temperature conditions, and it has also been indicated that good wearing properties of commercial cast iron appear to be associated with a good resistance to growth.

The subject now reaches the stage when we can make an appeal to the metallurgist. We can now tell him what are the worst conditions under which cast iron has to work, and we can ask him to tell us how to produce a metal that will retain its strength at the maximum temperature we might expect, that will not increase in size after a limited period of service, and that will resist wearing away under the rubbing action of the piston rings

Some Characteristics of Cast-Iron for Oil Engine Castings.

BY PROFESSOR A. CAMPION.

The successful development of the internal combustion engine depends in a large measure upon the ability of the metallurgist and founder to produce castings suitable for the components, especially the cylinder, cylinder cover, liner, piston, and piston rings. The special conditions under which the metal is to work have been very fully and clearly stated in Professor Mellanby's Paper, so that it is unnecessary to repeat them here.

The purely metallurgical aspect of the problem is of importance, because only special sorts of cast iron can withstand the temperature and stress conditions which obtain in oil engines. The properties and characteristics of these special qualities of cast iron differ in many respects from those of irons ordinarily employed for steam or general engineering castings, and the complicated nature of many of the castings demands from the foundryman great skill and initiative in devising the best methods of preparing the mould, placing and securing cores, venting, etc. It requires very careful consideration to determine the type of runners to be used and the position in which they are to be placed. An intricate casting requires that the metal used shall be capable of running into the thinnest portions and retaining its greyness; at the same time, it must make the thick parts dense and close-grained.

In considering the nature of the metal to be used it is not proposed to give detailed analyses of iron for any particular purpose, as these will naturally vary according to the size and intricacy of the casting, but rather to indicate the general metallurgical principles which have to be applied in determining the type of the metal to be used. The first requirement is that the casting shall be perfectly sound, as even a minute pin-hole in an oil engine cylinder or liner will render it useless. The term soundness has a very special significance when applied to these castings, owing to the heavy duty they have to perform under severe conditions. Slight flaws or imperfections which would be of small moment in ordinary castings would be fatal in a casting for an oil engine. The chief properties required are:—Soundness, the metal must be close-grained, with strong crystalline cohesion, and there must be freedom from draws or blow-holes. It must be of high tensile strength and other physical properties, and show constancy of form and dimensions, with high resistance to wear, and no cracking when submitted to high or fluctuating temperatures.

Principal Factors in Production of Cast Iron.

The main factors concerned in the production of cast-iron materials having these characteristics are:—(1) Composition; (2) melting and casting conditions; (3) rate of cooling and solidification; and (4) structural arrangement of the components.

As regards composition, the controlling element is the carbon, as all physical properties of the material are dependent upon the quantity and condition of this element present. The effect of all the other constituents being mainly according to the effect they have on the carbon and the compounds it forms. The total quantity of carbon in the iron is a matter of much greater importance than is commonly realised. The proportion of carbon which is in combination is always given much attention, and it is quite common to find statements about the combined carbon being the determining factor in regard to the strength and

hardness of cast iron, or to find specifications in which the percentage of combined carbon to be present is given without the slightest reference to the total amount of carbon present. The total carbon is a variable quantity, and with the same amount of combined carbon present there must obviously be a great difference between a metal with, say, 3.0 per cent. and one with 3.5 per cent. The nature, as well as the amount, of the free carbon may be different.

The total carbon for oil engine castings should be kept low, although it is not usually possible to get it much below 2.8 per cent., but it should not be present in a greater amount than 3.25 per cent. Silicon is a constituent of outstanding importance in determining the suitability of cast iron for any particular purpose. All cast iron contains silicon, and the proportion varies between wide limits. It exerts a powerful influence upon the condition of the carbon, and, consequently, the fluidity, hardness and other properties of the metal. Mr. F. J. Cook has devised a formula for determining the best proportions of silicon and carbon in metal, for any particular purpose:—

$$Sc = \frac{C}{4{\cdot}26 - \left(\frac{Si}{3{\cdot}6}\right)}$$

Sc = ratio of silicon to carbon.
C = percentage of total carbon.
Si = percentage of silicon.

For oil engine pistons, liners and parts requiring highest tensile strength Sc should be between 0.76 and 0.82, and for water-cooled cylinder heads or parts requiring high transverse strength Sc should be 0.83. The formula is empirical, but nevertheless is useful as a guide to the relative proportions of the two elements. Silicon usually varies between 1.0 and 1.5 per cent. Phosphorus may be beneficial or reverse, according to conditions, and consequently requires very careful adjustment. It gives increased fluidity and ability of the metal to take a clear and sharp impression of the more intricate parts of the mould, but if present in a large amount tends to reduce strength and make the iron brittle hard. In some quarters it is claimed that, for oil engine work, this element must be kept to the lowest limit (especially in America, where hematite is used), but the writer considers that this is not only unnecessary but undesirable. The maximum soundness and strength is obtained when the metal contains about 0.5 per cent., and it is advantageous to keep it round about this percentage, and to adjust the casting and cooling conditions so as to prevent segregation. Manganese is one, if not the most important constituent of cast iron for oil engine work, as it increases fluidity, closes the grain, tends to keep carbon in the combined condition, and acts as a powerful and efficient scavenger. It plays an important part in preventing changes in volume when the metal is submitted to high temperature conditions. It increases the stability of the carbide, and high manganese irons retain their strength almost completely at oil engine temperatures. They also machine easily and take a high polish. Sulphur when present in large amounts is objectionable, inasmuch as it decreases fluidity and causes blowholes, but moderate percentages, *i.e.*, 0.05 to 0.08 per cent. increase resistance to wear.

One of the principal means of securing permanency of strength and form is to increase the stability of the carbide, and to that end trials have been made of iron containing other elements such as tungsten, chromium, nickel, molybdenum, boron, vanadium, etc., but the results obtained have not been sufficiently good to warrant the extra cost. Chromium certainly reduces growth and retards dissociation of the carbides, and assists in maintaining strength, but the experience of the writer has been that equally good results are obtained more easily and cheaply by using manganese.

Melting and Casting.

The melting is probably best done in a reverberatory furnace, as it can be better controlled and the composition may be more easily and certainly adjusted and the desired casting temperature obtained, but good results can be obtained in a cupola, provided that it is of suitable design and under complete supervision. The casting temperature and the rate of solidification and cooling according to the thickness and contour of metal must be taken into account when deciding the composition to be employed in any given casting, as these are factors which exert much influence in fixing the constitution and structure of the metal upon which largely depend its properties. The ultimate chemical analysis, as usually stated, shows only the proportions of the elements present, but it is necessary to know the form in which they exist, and how they are distributed through the whole mass. The former is shown by a proximate analysis and the latter by the microstructure.

The structure of oil engine metal should exhibit a matrix consisting mainly of pearlite with the free carbon or graphite in small particles evenly disseminated through it. The phosphide should also be regularly distributed in small patches, or in the form of a mesh. Large plates of graphite, or large and segregated areas of phosphide, are to be avoided, as both are contributory causes of growth and deterioration of strength. Casting and cooling rates influence the arrangement of the constituents.

Table I.—Three different methods of expressing the composition of the same metal.

Ultimate composition.		Proximate composition.		Structural composition.	
	Per cent.		Per cent.		Per cent.
Total carbon	3.144	Graphite	2.334	Graphite	2.334
Graphite	2.334	Carbide of iron	8.775	Phosphide eutectic	8.680
Combined carbon	0.810	Carbide of manganese	0.342	Sulphide of manganese	0.303
Silicon	1.840	Phosphide of iron	5.572	Pearlite	72.936
Sulphur	0.110	Silicide of iron	5.520	Ferrite (by difference)	15.748
Phosphorus	0.868	Sulphide of manganese	0.303		
Manganese	0.510	—			
Iron (by difference)	90.384	Iron (by difference)	69.154		

It is commonly assumed that there should be sufficient combined carbon to make the matrix wholly pearlitic with or without free cementite in order to give a certain amount of hardness, but it is open to discussion as to whether this is the most desirable structure. Hardness is no criterion of wearing qualities; in fact, the hardest material often has the lowest resistance to abrasion, and has a tendency to crack under heavy or suddenly applied loads. What is wanted is a tough metal that can spread to a sufficient extent to form a highly burnished surface. If free cementite or large patches of phosphide be present, they are liable to break off and form a grit which increases wear. It appears that the most satisfactory result is obtained when the combined carbon is sufficient to give a matrix which is not quite all pearlite, a very small quantity of free ferrite. Pearlite may vary in form, and the most satisfactory is when it takes the form of very fine laminæ of cementite and ferrite.

The method of melting a mixture of steel scrap and pig-iron is to be recommended for the production of metal with the desired structure giving high strength, durability, and resistance to heat conditions. The material is known as "semi-steel," and has a particularly close and compact structure, machines well and is capable of taking a high polish. Its preparation, however, demands most careful attention to detail, measurement, or weighing of coke, pig-iron, scrap and air, together with skilled attention to all melting operations, which must be effected in a well-proportioned cupola. The structural composition and arrangement of the components are of the first importance in securing the desired properties and characteristics in metal to be used in oil engine castings,

and can only be obtained by strict attention to details and exact control of every operation. The difficulties of making intricate castings to meet such severe conditions are very great, and can only be surmounted by complete and cordial co-operation of all concerned, designer, metallurgist and foundryman.

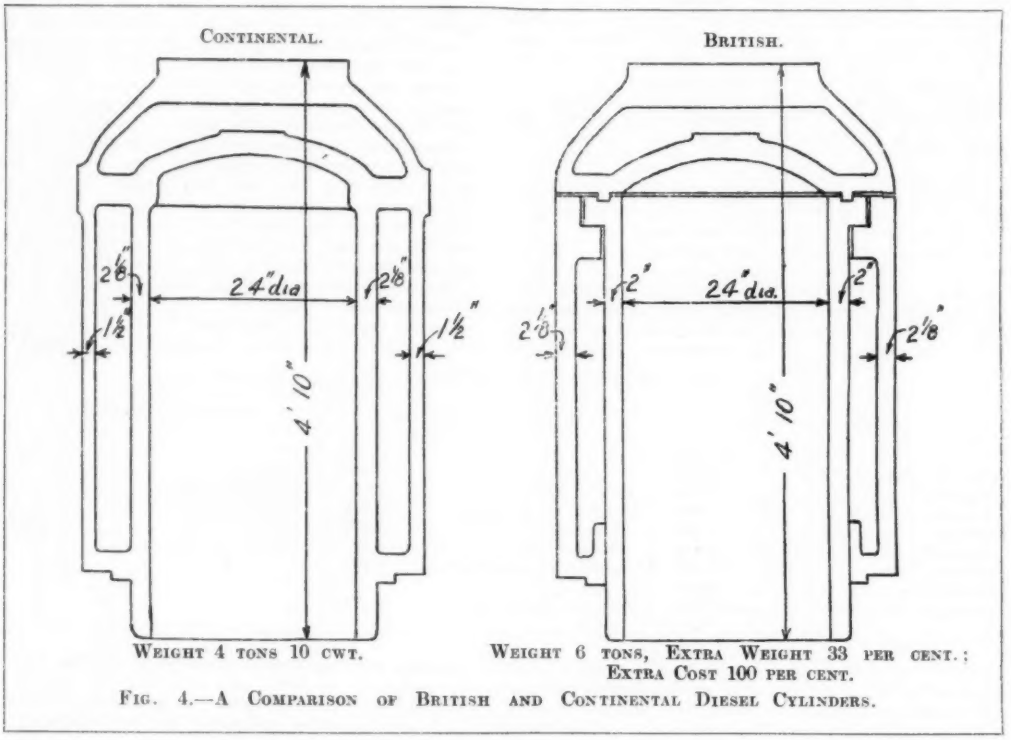
Oil Engine Design as Affected by Foundry Practice.

By JAMES RICHARDSON, B.Sc.

In the question of oil engines, particularly for marine purposes, constructors in this country are faced to-day with more severe competition than ever before in the history of this movement, and in order to meet efficiently the absolute necessities of the future, earnest collaboration between all parties concerned, such as the designer, the foundryman, and others, is essential.

It is unquestioned that the oil-engine makes greater demands upon the foundry than any other type of prime mover, since not only have high physical loads to be withstood, but stresses due to intense temperature may be combined with these loads. The author has prepared several diagrams to illustrate what occur to him as the principal points in this connection.

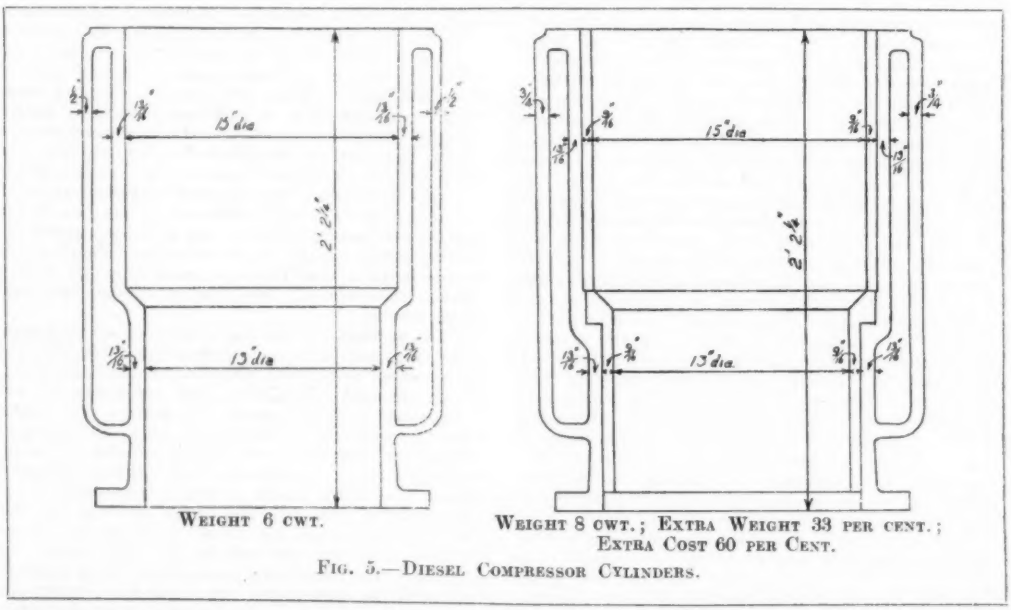
Fig. 4 shows, with dimensions, two designs of Diesel engine cylinders. That on the left is a Continental design. The variation in wall thickness will be noticed. This design is there regarded as a satisfactory solution of the problem, little or no difficulty being experienced in getting the requisite hard material on the inside of the inner barrel of the cylinder to withstand the friction of the travelling piston rings. British practice demands more even thicknesses of material, and in the author's experience sufficiently hard metal on the inside cannot be obtained in this country with the Continental design, so that the designer is faced with providing for an extra weight of 33 per cent. or an extra cost of not less than 100 per cent.



WEIGHT 4 TONS 10 CWT.

WEIGHT 6 TONS, EXTRA WEIGHT 33 PER CENT.; EXTRA COST 100 PER CENT.

FIG. 4.—A COMPARISON OF BRITISH AND CONTINENTAL DIESEL CYLINDERS.



WEIGHT 6 CWT.

WEIGHT 8 CWT.; EXTRA WEIGHT 33 PER CENT.; EXTRA COST 60 PER CENT.

FIG. 5.—DIESEL COMPRESSOR CYLINDERS.

Must the British designer perpetually be faced with this disability? Do considerable variations in thickness impose such difficulties on the foundry that such castings are a commercial impossibility? Can scientific cooling of the casting in the mould, to give chilling of the special surfaces in order to obtain the requisite degree of hardness and wearing properties, not be introduced as a commercial proposition?

The same point is further exemplified in the Diesel compressor cylinders as shown in Fig. 5, the extra weight due to maintaining relatively even thickness throughout, without what would here be regarded as thin metal, and the insertion of a special liner, being 33 per cent. with 60 per cent. increased cost.

In respect of cylinder liners as shown in Fig. 6, the question of the size of the head is important. What size of head is necessary to insure a sound

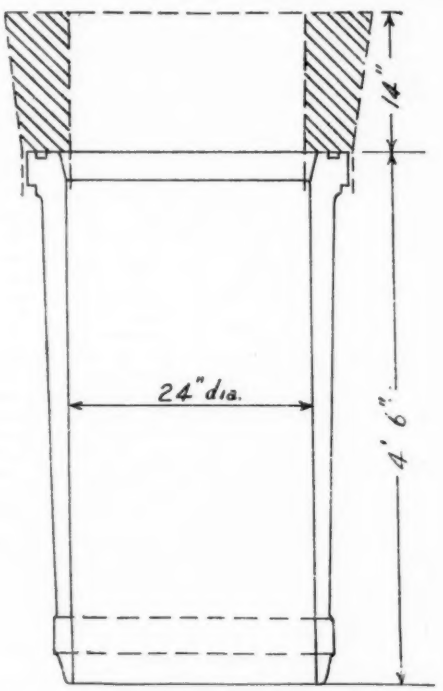


FIG. 6.—DIESEL ENGINE CYLINDER LINER. WEIGHT OF CASTING 1 TON 16 CWT.; WEIGHT OF LINER CASTING PLUS HEAD 2 TONS 5 CWT. EXTRA COST DUE TO HEAD 25 PER CENT.

casting? It must be remembered that the head represents extra cost, roughly in proportion to its weight. There seems to be no standard in foundry practice in this respect. The author has found that in order to get a requisite hard material for the working or inner surfaces of the liner, that chills introduced in the core are efficacious, although liable, due to the drawing action so generated, to set up hair cracks.

These few points occur to me as the most important with which British designers are faced, and a definite solution and ruling on these questions would be a decided advantage.

Oil Engine Design from a Foundryman's Point of View.

BY WILLIAM BELL.

From a foundryman's point of view, a great many of the failures in iron castings for oil engines are due to the design. Many of the designs involve internal stresses, which arise from the effects of crystallisation and graphite deposited during solidification, causing unequal contraction, porous and weak castings. This is undesirable at any time, but more especially in castings that have to be subjected to repeated heating. Now, in the manufacture of castings for oil engines, such as cylinders, covers and pistons, the foundryman's difficulties arise from the material cast into the moulds more than from the actual moulding, and although the demands of the engineer are increasing year by year for more complicated castings, the foundryman of to-day, with his greater store of knowledge to draw from, is in a better position to supply his demands.

When we consider the metal to be cast into the moulds, we must remember that the engineer is striving for a material with all the good properties of cast iron, and also with some of the good properties of steel. It is here that the foundryman's troubles begin, for, as one approaches the chemical composition of steel, one loses the valuable properties of cast iron, or in other words, when the carbon, silicon, and phosphorus, are reduced, the valuable properties such as low melting point, large range of fluidity, and expansion on solidification, which makes cast iron easily cast into moulds are lost. It is easier for the foundryman to overcome these difficulties if the casting has fairly regular thicknesses, or if it is possible to regulate the rate of cooling.

The conditions that oil-engine castings have to work under are so strenuous that one is inclined to ask the question, can cast iron stand up to it without failure? The iron must have a certain strength at normal and higher temperatures; it must wear well; it must not crack nor grow under repeated heatings, and it must not leak under water pressure. The metallurgist answers the question and proves that it can. By careful experiment he finds that an iron of specified chemical composition, cast under certain conditions, *i.e.*, noting the rate of cooling, gives the current structure and physical properties required by the engineer, but if this important factor is neglected, the structure may be coarse and the physical properties destroyed.

The careful designer notes all the conditions specified by the metallurgist, particularly the rate of cooling, and when he takes these into consideration in the making of his design, he places the foundryman in a better position to produce castings to the engineer's requirements. But the average draughtsman bases his calculations on the assumption that cast iron is a material that has the same strength throughout a casting, irrespective of the well-known fact that it is possible to cut two test pieces from the same casting and get results as high as 20 tons per sq. in., and as low as 4 or 5 tons per sq. in.—this difference being due to the different rates of cooling in the two parts from which the tests were cut. The foundryman knows, of course, that this is one of the most important factors in determining whether a cast iron will have the right structure to give the required physical properties or not, and they use every means at their disposal to equalise the rate of cooling, such as the use of densener, stripping the sand off heavy parts, etc., and if foundrymen could get the draughtsman to see the great importance of this function they would get a step nearer the realisation of castings to suit the engineer's requirements.

When the design of the castings gives fairly regular thicknesses the foundry metallurgist can use an iron of a definite chemical composition, after estimating what the rate of cooling will be, and obtain dependable results. If, on the other hand, the thicknesses vary greatly, iron of any given composition will not give the same structure in both thick and thin sections. The result must be a compromise at the expense of one or other of the sections. The thick section may be the most important, and naturally the foundryman would like to use an iron with the right chemical composition to give that part the right structure, but the rapid cooling on the thin parts would make them too hard to machine.

DISCUSSION.

In reply to Mr. Richardson's statement as to the comparison of British and Continental foundry practice, Mr. Bell said that he had great faith in the British foundryman. What could be cast on the Continent could be cast in Britain. The difference in the rate of wages and the hours worked per day might give the Continental foundryman an advantage in the cost of production, but he believed the advantage ends there.

The British engineer was respected all over the world for his high class workmanship, and the British foundryman had made it possible for him to hold that position.

Fig. 4 showed two designs of Diesel engine cylinders—the British one was built up of three castings, while the Continental one was cast in one piece. When the nature of cast iron is considered, together with the size of the casting, and the high physical load to be withstood, this design had nothing to recommend it, but if the cover was cast separately—and he believed from an engineering point of view this would be an advantage—the rest of the casting should present very little difficulty to the British foundryman.

The variation of thickness in the two walls, 1½ to 2¾ in,, should not make it impossible for the British foundryman to cast with a reasonable amount of hardness in the barrel. The outside thickness on such a casting as this would always contract more than the inside, internal stresses were liable to be set up, and a stronger casting would result from reducing the inside thickness and increasing the outside without materially interfering with the weight. The air and exhaust ports were not shown on this design, and it was generally these details that caused unequal thicknesses.

Fig. 5 showed two designs of air compressor cylinders. From a moulder's point of view, the Continental design would be the easiest to mould, the greater space between the two thicknesses would allow a stronger jacket core to be used. On the other hand, if the British design is accepted, the space between the outer and inner walls increased, keeping the thicknesses the same, many of our foundries could produce such a casting with the inside sufficiently close grained to eliminate a liner.

With regard to Fig. 6, the question may be asked, what size of a head was required on a liner of this description? If this casting were cast without a head, the top part being heaviest, would solidify last. The crystals start to grow at right angles to the cooling surface, gradually getting larger as they near the centre, the bottom feeds away the liquid metal leaving the heavy part at the top porous. He would not say that a head of 14 in. was required, but it was necessary to put on a head sufficiently high to ensure that the last part to solidify was in the head that was to be cut off.

The foundryman generally kept on the safe side, and it was better to have an inch extra than an inch too little, and if a sounder casting was produced by putting on a head, the extra cost was justifiable. In conclusion, he again reminded draughtsmen or designers to consider well the rate of cooling when designing for cast iron castings.

MR. J. E. HURST said, that after listening to Dr. Mellanby's Paper, two points of great importance to those interested in Diesel engine castings emerged. Both these points centred round the fact that the resistance to distortion under heat influences, and the resistance to wear, as pointed out by Dr. Mellanby, were almost synonymous terms, and at the same time cast iron of the type giving a low growth figure were the best type for Diesel engine cylinder construction. The first point he would like to make was that, if this was the case, it was perfectly easy and eminently necessary to specify some property which would differentiate between satisfactory and unsatisfactory irons for Diesel engine cylinder construction. He suggested that it would not be difficult to specify a resistance to "growth" of the type shown by Dr. Mellanby in his best sample. This would at once provide a means for differentiation between irons for Diesel engine work, and would enable those who had irons to offer for this purpose to have recourse to some test which would assist them in assuring designers to whom they presented these irons, that they could at least offer them something equal, if not superior, to what they were at present using. The absence of any such test in the past had hampered metallurgical men very considerably in improving the quality of iron for Diesel engine purposes. The fact that resistance to distortion and resistance to wear were almost synonymous terms was also, in the second place, a fact of intrinsic interest. If the resistance to distortion was due to the stability of the pearlite carbides, then the resistance to wear was due to the presence of pearlite, or conversely, if the resistance to wear was due to the presence of the pearlite carbide, then the resistance to distortion was also due to the presence and stability of this constituent. This was a point of considerable importance to the metallurgist. He thought all metallurgists would have liked to have heard from Dr. Mellanby some opinion as to whether or not the severity of the working conditions sustained by high-speed internal-combustion engines of the petrol-engine type were at all comparable with those sustained in engines of the large Diesel type. Some such statement, if it could be made, would help metallurgists very considerably in fixing their ideas. In one respect alone such a statement would be of value, as in the case of the former it was a much more simple and inexpensive business to try out castings in the smaller petrol engines than in the large Diesel engines. With regard to Professor Campion's Paper, he might call attention to the fact that manganese in the presence of silicon did not preserve the carbon in the combined condition. It had been frequently shown that under these conditions, other things being equal, the exact opposite was the case. This was a very general error amongst foundrymen, and it was for that reason that he took the opportunity of pointing out the mistake. He was greatly interested in listening to the remarks of Mr. Richardson, which were extremely sound and very much to the point. With Mr. Richardson, he was quite sure that Diesel engine castings equivalent to anything that had been done in Continental practice could be produced in this country. He could not refrain, in concluding, from calling attention to the centrifugal casting process for the production of cylinders and piston rings. Fundamentally the process offered the only solution at present to the production of cylindrical castings with assured freedom from internal defects and porosity. With this process for Diesel engine liners, given certain conditions of quantity production, cast iron of exactly the same composition as that used in the sand-casting methods could be cast centrifugally, and, apart from the assured soundness of the castings, centrifugal castings made an enormous improvement in the tensile strength and resistance-to-wear conditions over the same material sand cast.

Foundry Query.

Cast-iron Melting Pots.

We have been making some cast iron melting pots for melting about a ton of lead over a coke fire, and considerable trouble has arisen owing to the fact that the lead gets out of the bottom of the pots after a few weeks. The metal at the bottom is 2½ in. thick.

Up to the present the job has been made to leave its own core. It is possible that a sounder casting would be obtained if it were cored out. Do you think there is any hope of making a pot which would withstand the conditions above mentioned for any length of time, say three months.

Can you advise us as to any special mixture in iron, which would be better calculated to withstand the heat.

If you can give us any assistance in the above problem, we shall be deeply grateful.

"MINER."

WITH THE OBJECT of forming a Midland branch of the Institution of Structural Engineers, to include the counties of Hereford, Shropshire, Staffordshire, Derbyshire, Nottinghamshire, Northamptonshire, Worcestershire, Warwickshire, Leicestershire, and Rutland, a meeting was held at Wednesbury recently. The chair was occupied by Major James Petrie, president of the Institution, who said the scope of engineering widened with every invention and every discovery, and every year some fresh field of research was opened. In proposing the formation of a Midland branch of the Institution, Mr. W. R. Parsonage (Wednesbury) said the Black Country had become one of the greatest constructional engineering centres in the country. The resolution was carried, and Mr. W. R. Parsonage was elected hon. secretary.

French Foundry Congress.

[FROM OUR PARIS CORRESPONDENT.]

The fourth annual Foundry Congress, organised by the Association technique de Fonderie, was opened on November 21, at the Conservatoire des Arts-et-Métiers. Its inaugural session was presided over by M. Dufour, President of the Syndicat des Fondeurs de France.

The Congress comprised five sessions, the closing one being held on Sunday, November 23, and each session was assigned to the consideration of an important question.

"Utilisation of Special Pig-irons."

Mr. A. Campion, F.I.C., of Glasgow, submitted to the Congress, on behalf of the Institute of British Foundrymen, a Paper on "Some Factors which Influence the Strength of Cast Iron," in which he emphasised that the examination of defects and their causes was essential to promote technical progress in foundry practice.

Mr. Campion drew attention to the indefiniteness of the strength in complicated castings. He gave as the principal factor which influences strength the constitution of the cast iron, which is determined by the initial casting and solidification temperatures, in conjunction with the rate of cooling. Examples were cited indicating that a test bar is no criterion of the strength of a casting.

The structure of cast iron is also a very important factor. It must contain about 0.9 per cent. of combined carbon for attaining a maximum strength. Silicon is next in importance. The quality principally required from a casting is soundness. One of the most serious defects to be avoided is porosity, which may be due to various causes. The strength of cast iron is influenced by reheating, or other heat treatments. It decreases if the reheating temperature is taken beyond 500 deg. C.

Special Pig-Irons from Hagondange Ironworks.

This contribution, by M. Roehrich, was a mere exposé of a new departure of the Hagondange Ironworks, in Lorraine, which are in a position to supply at one time 20 tons of perfectly homogeneous pig-irons, made in converters, with compositions varying to suit the requirements of customers. Low carbon pigs are thus obtained which are difficult of manufacture in blast-furnaces.

The Société Alsacienne des Fontes Mécaniques uses "semi-steel" from Hagondange for rolls, and Renault its semi-phosphoric pigs for motor-car cylinders.

"Mechanical Characteristics of Special Pigs."

This Paper, by M. Jacques Varlet, foundry manager to the Société Métallurgique d'Espérance-Longdoz concern at Seraing, was presented on behalf of the Association technique de Fonderie de Belgique.

M. Varlet said that the special pigs made before 1900 were superior to those made now, because they were obtained in small furnaces with cold blast. With a similar analysis for both, pigs now being made were less homogeneous than previously so far as grain, hardness and strength are concerned.

Foundry Sands.

At the second session, which was presided over by M. RONCERAY, Directeur de l'Ecole de Fonderie, the first Paper to be presented was a "Review of the Physical Characteristics of Sands for Foundry Practice," by M. L. Deltour.

This study of the plasticity of foundry sands involves the consideration of the following points:—Deformation, cohesion, adherence, plasticity in the restricted meaning of that word. The author enumerated the principal theories bearing on plasticity as (1) physical phenomenon of "suspension"; (2) excess of water, not only saturating the sand by means of the capillary canals, as in a sponge, but also enveloping the surface of the particles of sand; and (3) lamellar structure of sand and clay particles.

One member insisted that the last phase was never encountered; sand particles were either rounded or angular. Owing to the absence of the author, this discussion was not pursued further.

"The Influence of Moisture, Dust, and Clayey Matter on the Permeability of Moulding Sands" was the title of a Paper by Messrs. Harrington, MacComb and Hosmer, which was presented on behalf of the American Foundrymen's Association.

The Paper outlined the experiments made by the authors with the object of defining these influences. The methods they used were those suggested by the Moulding-Sand Sub-Committee of the American Foundrymen's Association, and they were carried out on sands prepared for use—that is, old sand milled with new. The experiments continued 19 consecutive days, and their findings are therefore of average value. The results apparently confirm the theory that if moisture, dust, and clayey matter contents exceed a certain limit, a decrease of the permeability results. The conclusions emphasise the value of the testing methods advocated by the American Foundrymen's Association.

"A Technical Research on Moulding Sands" was the title of a contribution presented by M. Gramme, ingénieur, chief chemist to Société Française des Constructions Babcock et Wilcox.

Chemical analysis furnishes at the present time the only available method of checking the quality of consignments of sands, but it gives no information as to the actual constitution. A sedimentation test is quite useful, but the one recommended by the author is to take a test tube 50 cms. high and 18 to 20 mms. dia., and fill it with 10 grs. of sand; 10 c.cs. of hydrochloric acid are added, and the mixture shaken. Then add 15 c.cs. of commercial petrol, and shake once more. Finally, the tube is filled with fresh water and shaken again for two or three minutes. On settling, the colloidal matter remains with the petrol, the clay matter comes next, whilst the silica is at the bottom of the tube.

Grain size, their chemical composition and physical analysis, were each dealt with in turn, and the author concluded by giving his opinion on moulding sands in general, and defects in cast iron directly attributable to them.

M. Formel, a professor attached to the Ecole de Fonderie, suggested a research to ascertain when and under which conditions sand lost its essential colloidal constituents.

In a Paper entitled "The Quality of Sands Used in Foundry Work," M. Saillot, ingénieur-fondeur, drew attention to the interest of using of weak sands which will carry a relatively large addition of water. If strong sands were to be used, they must be employed very dry. He asked for a systematic exploitation of some little-known sand deposits, taking care to exclude the adjacent clay seams, and finally dealt with the preparation of a certain number of sands which had given satisfactory results.

A member pointed out that sand should be moist for the addition of coal dust, for the mixture was thus in suitable condition for bringing about the intimate contact of the grains of the mixture as a whole.

"The Testing, Treatment, and Utilisation of Moulding Sand" was the title of a contribution given by M. Pascal. The examination of sands in the foundry was generally left to one of the workmen. This was the reason why opinions differ so widely from one plant to the other, since there was no precise method used. The following tests were recommended:—(1) Chemical analysis of the sand dried at 110 deg. C.; (2) exact determination of the proportions of silica and clayey matter; and (3) chemical analysis of the argillaceous matter. The structure, size, and form of the sand grains are important factors for the three essential qualities of sands—plasticity, permeability, and refractoriness.

Blow-Holes in Cast Iron.

The third session was presided over by M. DAMOUR, Vice-President of the Association Technique de Fonderie, and the first Paper to be presented was "Blow-holes from Cold Iron," by M. Devaux, ingénieur, E.S.F. Blow-holes are generally attributed to an excess of sulphur in the iron, but recent experiments have led to the consideration that by operating in different ways with the same charge one can obtain at the same time both sound and blown castings, even with a low sulphur content. Blow-holes depend on temperature of the iron and of the manner of handling it.

Foundry Defects.

"A Few Experiments with Chaplets," a Paper by M. Mazenot, was also presented as a contribution under the general heading of 'Foundry Defects.' The question of the water-tightness of finished castings is one that causes much difficulty to foundrymen. The leaks are due quite frequently to chaplets.

M. Mazenot dealt with a number of experiments relative to chaplets, such as the testing of the strength; the influence of the thickness of the metal; the condition of the surface; the influence of gas bubbles trapped in under double-headed chaplets; and various welding experiments. The experiments showed that chaplets did not require to be tinned provided that they be kept perfectly clean.

The author was of opinion that there was no necessity to heat up the chaplets before casting, but one of the members insisted that a certain amount of heating was desirable, and that it was sufficient, to prevent oxidation, to control temperature so that it did not exceed 150 to 200 deg. C.

The third Paper bore the title, "A Comparison of Foundry Tests," and was a contribution by M. de Fleury. The author recapitulated the properties of metals as influenced by the many variables, such as rate of cooling; sudden loss of "life"; solidification range; volume of occluded or trapped gases; contraction or solidification; co-efficient of expansion, and physical changes. "Piping" was stated to be governed by the extent of shrinkage during solidification. Cast iron was not subject to that law, but steel and aluminium are influenced by it.

M. Fleury finally dealt with "bad patches," which crop up in every works. They would not be overcome by the larger incorporation of virgin metal, but rather by modifying existing moulding methods.

"Tentative Classification of Defects in Grey-Iron Foundry Practice," by M. Debar, was next discussed. This was an attempt to introduce order in the complicated question of foundry defects. The proposed classification was based on the most important causes of such defects. They are defects due to the pattern; to the mould, to casting, to the metal itself; and to handling and operations performed upon the finished casting. In his conclusions the author recommended the provision of clean, well-ventilated, permeable moulds and cores, and the prevention by some means of slag entering the mould. Finally, a proper sulphur-manganese balance must be maintained.

An important Paper, entitled "Defects Due to the Presence of Sulphides and Oxides in Cast Iron," was presented by M. Piedbœuf, a Belgian foundryman. It outlined a new process for the desulphurisation and deoxidation of cast iron. The defects due to sulphides are brought about by the uneven distribution of such sulphides in the castings, causing the rapid atmospheric oxidation of those parts containing an excess of sulphur, resulting in blow-holes; blisters ensue, hard spots, and increased shrinkage, with accentuated piping and casting stresses in the casting.

A M. Walter had developed and patented a process for dealing with this problem. It was based on the use in the receiver of alkaline and earthy-alkaline salts suitably mixed. The sulphur content could thus be lowered by 50 and even by 75 per cent.

"Mould-gas Blow-holes" is submitted as a translation of "Pourritures," the title of an interesting and practical Paper by M. Léonard, a past-president of the Belgian Association. "Pourritures" are caused by the combustion of materials contained in either mould or core, which become trapped during their escape into the adjacent metal, causing a type of blow-hole.

A few hints were given for avoiding this defect, as for instance, the running of a casting at its thinnest part; others were clearly shown by rough sketches.

Standardisation of Patterns.

This subject was dealt with at the fourth session, which was presided over by M. Thomas, foundry manager to Citroen.

The first paper to be read was "An Attempt at Pattern Standardisation," by M. Quérut, a Belgian patternmaker.

After having dealt with the situation of the problem abroad, notably in the United States, the author enunciated the following principle:—The standardisation of patterns necessitates a preliminary standardisation of castings, and the latter has not yet advanced very far. For the present, it is necessary to limit the proposition to the standardisation of some elements: the system of patternmaking; sectioning of patterns; dowelling; screwing together of patterns; crossing of patterns; core prints; loose pieces; recesses; strickling board design; core boxes; putting cores in prints; and the painting of patterns. If such a standardisation could be accomplished, it would be possible to reduce the cost price of patterns by 25 per cent. It was elicited during the discussion that the French Compagnie des Chemins de fer de l'Est had established a technical specification for its patterns with a few tolerances. If all foundries were not in a position to do the same, at least there ought to be an average specification that should be accepted by all.

"Pattern Standardisation," a Paper by L. Thibaud, was next presented, who said that if the following principles were established, the standardisation of patterns would rest on a proper foundation:—simplification of moulding operations, and the use of cores to the greatest possible extent. On the other hand, the standardisation will enable the draughtsmen and the patternmakers to find out rapidly the method proposed for the moulding, that is whether horizontally or vertically.

The author also dealt with patterns necessitating the use of two-part and multiple moulding boxes, and their standardisation, as well as the standardisation of core boxes.

Foundry Costing.

The fifth and final session dealt exclusively with foundry costing, a subject which is being prosecuted energetically by Belgian, American and German foundry associations, but unfortunately not by the British.

Grain Growth in Mild Steel.

Before a meeting of the Staffordshire Iron and Steel Institute at Dudley on November 21, 1924, MR. FRANCIS S. DODD read a Paper on "Grain Growth in Mild Steel," in the course of which he pointed out that normal grain growth occurred in any metal (except cast metals) which was heated for a sufficient time at a sufficiently high temperature. When a metal was plastically deformed in the "cold" and then annealed under suitable conditions, very large grains resulted. Any excess of strain beyond a certain point caused the metal to totally recrystallise if annealed at the proper temperature. This was followed by grain growth if sufficient time was allowed.

The object of the present work was to conduct quantitative experiments with regard to abnormal grain growth in steel. The main points to be investigated were: (1) To ascertain the limiting amounts of carbon which would give abnormal grain growth in steel; (2) to ascertain the relation between the amounts of strain and the temperature of annealing, below 700 deg. C., and (3) the effects of varying carbon content on (2). The materials used in the investigation were Armco iron and mild steels of varying carbon content.

The experiments (concluded the author) showed that abnormal growth did not occur in Armco iron whatever the degree or kind of deformation when annealed at 650 deg. C., but all mild steels containing up to 0.25 per cent. carbon would, if sufficiently plastically deformed, grow large grains upon annealing between 600 deg. C. and 700 deg. C. If the temperature of annealing was too low no exaggerated grain growth would take place, however great the deformation. The grains in a strain hardened steel which had been annealed at too low a temperature to produce growth would, upon re-annealing at the proper temperature, grow as if it had received no previous annealing.

The Scientific Principles of Centrifugal Casting.

(*Continued from page 297.*)

The continuation of Carl Pardun's Paper in "Stahl und Eisen" deals with the segregation of the constituents, the micro-examination and determination of density of centrifugal cast iron.

It was to be expected that the constituents segregated during the interval of solidification would be deposited inside the wall of the casting, according to their specific gravity. Since, owing to the quenching effect, the outermost zone cannot share in this segregation, the maximum of a constituent migrating outwards and the minimum of a constituent migrating inwards must lie at a certain distance from the outside. With a view to ascertaining the extent of such segregation, a few bars of material taken from pipes in which quenching was scarcely present and which were unannealed were split up into layers about 2 mm. by planing them, the "skin" being allowed to remain. Fig. 1 (curves) give the results of these tests, the abscissæ being the intervals between the layers and the ordinates the percentages found. The left-hand side of the curves represents the outside and the right-hand side the inside of the pipe wall. The curves show the following phenomena to occur:—

FIG. 1.—SHOWING THE MIGRATION OF ELEMENTS IN CENTRIFUGALLY CAST CAST-IRON PIPES.

The silicon was found to be quite stable, being uniformly distributed over the cross-sectional area of the wall. As was stated in the introduction to this Paper, only substances in suspension and not in solution can be segregated by the centrifugal force. The silicon is present in the material as a solution, and hence no migration takes place, and the silicon curves are therefore horizontal. Manganese and sulphur segregate on the inside. Phosphorus exhibits marked segregation on the outside—a fact that has already been shown by Hurst. On the other hand, Burgess found that in steel there was a migration of the phosphorus inwards. The carbon also segregates or accumulates on the outside in the form of graphite. The maximum of elements migrating inwards, viz., sulphur and manganese, is found in the inner skin of the metal, and the maximum of elements migrating outwards, viz., phosphorus and carbon, at a distance of from 2 to 4 millimetres from the outside, the distance corresponding to the depth of the quenching effect.

The main factors producing this phenomenon are the solubility, melting-point, and specific gravity of the constituents of the structure. We already know that iron sulphide is not soluble in γ-iron. Manganese sulphide has a high melting-point, and thus segregates at an early stage from the melt. It is therefore possible for both, owing to their low specific gravity, to concentrate on top of the mother-liquor, the specific gravity of which is much higher, *i.e.*, it may accumulate on the inside of centrifugal castings. The rising of the sulphides in an iron bath is a recognised phenomenon. Sulphur segregation was determined by making the Baumann sulphur test. All the specimens of centrifugal castings show a marked accumulation of the sulphides at the inner zone. In fact, we may call the concentration a partial deposition, as the sulphide concentrations lie in the skin of the casting.

This internal migration of the sulphur is valuable in the case of centrifugal castings that have to be machined, such as cylinder liners, roller jackets, and piston rings. The machining completely removes the high-sulphur zone, and so greatly improves the material. A few of the pipes examined also exhibited sulphide accumulations in the outer zone. Probably segregation could not take place at these points owing to the rapid cooling of the metal.

So long as manganese is combined with sulphur, it migrates towards the inner zone. If the amount of manganese combined with sulphur is deducted from the total manganese, it is found that the residual manganese is practically equal in extent in all zones.

This would seem to be further proof of the assumption that the sulphur in cast iron containing manganese is practically all present in the form of manganese sulphide, while the remaining part of the manganese is in solution. The centrifugal effect seems therefore to afford a possibility

of determining the nature of the constituents in systems built up of a number of constituents.

Migration of Carbon.

The concentration of carbon on the outside in the form of graphite can be explained by the iron-carbon diagram. It does not conflict with Burgess's statement as to the concentration of carbon on the inside of centrifugally cast steel. Taking Goeren's diagram and the special cases that he mentions of two alloys of 0.3 per cent. and 3.2 per cent. carbon, which may roughly represent the two cases with which we are now dealing. The mixed crystals which segregate primarily to the left of the point E (1.7 per cent. C.) concentrate on cooling at the expense of the total carbon content of the mixture. Thus, the example mentioned by Goerens of a steel alloy at 1,460 deg. C. contains:—

22.8 grams of the mother liquor with 0.75 per cent. C.		=0.17 gr. C.
72.2 ,,	of crystals with 0.17 per cent. C.	=0.13 ,, C.
100 ,,	mixture	=0.30 ,, C.

The crystals segregated therefore contain nearly half the total carbon. Shortly before solidification (point F) the crystals have practically the same carbon content as the melt, and they have migrated inwards owing to their lower specific gravity, so that at that zone there is an accumulation of carbon. Taking the same calculation for the alloy with 3.2 per cent. carbon at 1,130 deg. C., we get:—

59.7 grams of mother liquor with 4.2 per cent. C.		=2.51 gr. C.
40.3 ,,	of crystals with 1.7 per cent. C.	=0.685 ,, C.
100 ,,	of mixture	=3.195 ,, C.

Whereas the unsaturated crystals to the left of the point E can gradually accumulate through diffusion, this is not possible with the saturated crystals to the right of E. In alloys of over 1.7 per cent. C., the high-carbon melt solidifies at the end of the interval, whereas a portion of the lower-carbon crystals has already been segregated.

The fact of phosphorus concentrations occurring on the outside is explained by the low melting-point and high specific gravity of the phosphide eutectic. Its melting-point is 922 deg. C., and in the purely ternary system it is 950 deg. C. The eutectic is forced centrifugally between the eutectic carbon melt, which, cooling last of all, accumulates on the outside, and it is at that point that the eutectic actually concentrates.

The various conditions of casting were determined in so far as they affected segregation. For this purpose a test sample was taken from each centrifugally cast pipe, in the outer, middle and inner zones, and these were analysed.

Chemical Discrepancies Explained.

These analyses taken from the three zones confirm, for annealed pipes, the migrations already found for unannealed pipes. It was found that the conditions of casting, such as increasing speed of rotation, varying composition and varying temperature of casting have no logical influence on segregation. With a wall thickness of 13 mm. (½ in.) the quantity of material is too small, and the rate of cooling too rapid for any great amount of segregation to occur. In larger masses of metal, segregation would doubtless take place, especially at high casting temperatures.

From a comparison of the analyses of sand castings cast from the same iron with the zone analyses of the centrifugal castings, it is shown that the silicon and phosphorus contents exhibit no alteration, whereas the manganese and sulphur contents of the sand castings are sometimes higher than the mean contents of the three zones. This phenomenon is probably due to the fact that on this occasion the skin was removed from the centrifugal castings before taking the test pieces, thus eliminating a considerable portion of the sulphide concentrated on the inside.

It is surprising that the total carbon content of all centrifugally cast pipes is lower all through than in the corresponding sand castings, and the writer attributes this to a mechanical deposition of hyper-eutectic graphite during the spinning of the pipe.

From considerations which he adduces, the writer thinks that, for the centrifugal process of casting, an alloy having a cooling interval as small as possible is desirable, so as to prevent large amounts of mixed crystals segregating, which give rise to faulty places when the metal band is being formed on the rotary mould. An alloy of this kind would be a eutectic alloy, and the occurrence of such an alloy is perceptible from primary graphite deposited inside the pipe. Many writers advocate a high silicon-content, but this seems to have been arrived at empirically.

Annealing and Size of Graphite.

In the literature on the subject, there are numerous papers on the effect of the nature of the graphite on the properties of grey cast iron, and all investigators seem to be agreed that when the graphite is finely divided its effect on the strength of the metal is good. The present writer made a number of graphite studies on samples of centrifugal- and sand-cast pipes, and he finds that the increased strength of centrifugally cast pipes is due to the fine distribution of the graphite, and that this fine structure does not suffer by annealing the pipes for a short time. A careful investigation carried out on a sand-cast pipe 12 in. dia. and 15½ ft. long, showed that no segregation had taken place, and ½ in. wall thickness being so slight as not to retard the very quick rate of cooling. These particular tests go to show that the fine character of the graphite is not caused by centrifugal force or ferro-static pressure, but simply by the very great rate of cooling.

Cause of Enhanced Properties.

The present experiments show that the cause of the improved qualities of the metal are:—(1) The partial segregation of the sulphur into a neutral zone; (2) the distribution of the phosphorus in a finer form; (3) the very uniform deposition of the graphite in a refined form similar to temper carbon; and (4) the reduction in the size of grains.

From the preceding observations, no considerable increase in density was expected which could account for the improved mechanical qualities of centrifugal cast iron. In order to investigate this question, nearly 100 density determinations were carried out on sand-cast material, and on centrifugally cast material that had and had not been annealed. The samples were small prisms cut out of the test bars, and the tests were made in the specific gravity bottle (pycnometer) in water at 15 deg. C. Whereas the figures in most of the series agree pretty well, as regards sand castings, there is in series C a decrease in density with increasing phosphorus content. There are considerable variations in the figures for annealed and unannealed centrifugal castings, due probably to the fact that the quenched layer of the test piece had been machined off. A comparison will show that the density of the sand castings closely approaches that on the unannealed centrifugal castings, whereas the annealed centrifugal castings had undergone a considerable reduction in density. Its mean density is about 7.0, and fluctuates from 6.795 to 7.162.

Density and Growth.

Many workers attribute this decreased density to growth in the cast iron set up by heating it. Outerbridge, Rugan and Carpenter found that grey cast iron when heated commences at once to grow, whereas white cast iron at the beginning shrinks slightly and does not commence to grow until the combined carbon has been transformed. This explains the great diminution in density in the series F, B, C, D, E, which had only suffered a slight quenching action, whereas the pipes in series A, which had been quenched to a depth of 4 mm. (⅛th in.) show a much smaller reduction. The extent of growth depends on the period of heating (annealing). Another writer found that the growth is due to the decomposition of silicide of iron into silicic acid and ferrous oxide due to the absorption of oxygen. The fact of the increase in volume depending on the period of annealing explains why a short period of annealing such as is used for centrifugally cast pipes does not unfavourably affect the strength properties of the material.

A Paper recently published by Oberhoffer, Piwowarsky and others on the gas and oxygen contents of cast-iron very strongly confirms the above statements. These writers found, in cast iron, percent-

ages of oxygen up to 0.5 per cent., and found an increase in tensile and transverse strength, but a decrease in impact strength, with increasing percentages of oxygen in the metal. They laid down this increase in strength to a refining of the graphite lamellæ. To afford brief confirmation or otherwise, the present writer made a few oxygen determinations in sand castings and centrifugal castings by the hot extraction method. The following table shows the results:—

Sample No.	Sand cast.	Centrifugal Cast.		
		Outside.	Centre.	Inside.
	Per cent.	Per cent.	Per cent.	Per cent.
A4 ..	0.19–0.22	0.19–0.21	0.20–0,23	0.29–0.31
D6 ..	0.19–0.22	0.17–0.18	0.18–0.20	0.28–0.34

The results show that the oxygen content of sand-cast metal corresponds with the outside zone of centrifugally cast metal, a proof that no increase has taken place due to the effect of annealing. Nor can any increase be observed in the middle zone, but the inside shows an appreciable increase in the oxygen content, this increase amounting to 50 per cent. of the content of the outer zone in the test samples examined.

These few determinations do not afford any conclusive proof as to the effect or otherwise of oxygen in centrifugal castings. The concentration seems, like the sulphides, to be restricted to the inner zone. As the oxygen content, at least up to the middle of the pipe wall, seems to be approximately equal to that in the sand-cast pipe, the increase in mechanical strength observed in the present investigations cannot be attributed to a variation in the percentage of oxygen.

The Standardisation of Foundry Patterns.*

By J. Masviel.

Considered as a whole the scope for the pattern-maker is limited because his chief function is to materialise the ideas of the designer into forms that can be utilised by the moulder. The determination of these forms and the facility with which they can be used are intimately related to the equipment and labour at the founder's disposal. The design of the pattern and the relative disposition of its parts are beyond the patternmaker's control, being determined by the requirements of the engineer and the moulder. Under these conditions it becomes impossible to lay down rigid rules for the construction of the pattern until the castings themselves and the methods of moulding are also standardised. At present the lack of liaison between designer and moulder is a serious handicap to this advance. By aiming at the design of certain features which shall best fulfil their particular purpose, it is possible to standardise those features. This accomplished a schedule of charges for the construction of the pattern can be drawn up. A possible objection to this method is that it might tend to destroy the workman's initiative. On the other hand an enlightened patternmaker would be satisfied to see the best ways and means of his art officially recognised. The methods of procedure could be definitely fixed and the charges—which always appear unduly high—could thus be justified. It appears, then, that even a partial standardisation would have numerous advantages. The customer, engineer or founder could more easily draw up the specification of the part. It would be possible to produce an article of the best design at a price which would fall within easily ascertained limits. The patternmaker would feel less tempted to cut down his manufacturing costs to meet competition by sacrificing strength and good workmanship in the pattern.

Since the design has been discussed with the moulder he, too, will benefit from the better arrangement of the pattern and the standardised method of working. Conventional colouring, chosen by all concerned, of the various parts of the pattern, core prints, loose pieces, etc., would greatly facilitate its passage in the foundry. Technical and professional data, too, would be improved by standard methods, and apprentices would benefit considerably by the establishment of fixed rules covering the best practice. The close examination that must precede the drafting of these rules will enable a comprehensive knowledge to be obtained of regional processes and practice. A wide publicity of the aims of the research would be of great benefit to the foundry trade by tapping widespread sources of knowledge. It is not suggested that every pattern should be made on the same lines, but it is necessary that the price of the pattern should bear a reasonable proportion to that of the casting. The construction of a pattern may be placed in several categories according to the number of castings to be made from it, but in each category the details of construction would be clearly defined. The establishment of such rules would entail a great deal of work that would be beyond the powers of one worker. Active collaboration of all interested sections would be essential if the best results are to be obtained. The research might be undertaken by a committee of all interested in the production of patterns on sound, scientific lines. The committee would include the manufacturer, who, after all, buys the pattern; the customer, who pays directly or indirectly; the moulder who uses the pattern and is in the best position to criticise its design, the patternmaker who makes the pattern, and should certainly have some say in the matter; and finally the technical staff who have to put the recommendations of the committee into practice.

The first step is to specify the categories under which the patterns will be classified. A tentative classification would be as follows:—(1) Patterns from which large numbers will be made, fillets cut in the solid, fragile parts made of metal lateral drawbacks on keys, all box fittings of metal; (2) patterns for moderate numbers, fillets cut in turned parts only, leather fillets in other places, metal fittings confined to letters, numbers, lifting and rapping plates. Both the above classes have dowelled joints; (3) patterns of average construction as above, but with filleting indicated by paint on parts that are removable; (4) light patterns, fillets indicated by paint, dowels only where necessary, drawbacks on screws or draw pins; and (5) skeleton patterns.

With these various categories clearly defined, the next step would be to revise those details of construction which have a direct influence on the moulding facilities, such as the surface finish, the form of drawbacks—considered with reference to their relative position; the methods for locating and fixing loose parts, whether by pins, screws, wires or keys; the position and form of gates; core boxes, which would be classified in types and according to the patterns with which they are to be used. Following the standardisation of these features, attention would be directed towards actual methods of construction according to the category in which the pattern is placed. The dimensions and solidity of the various parts would be proportioned in accordance with their duties. Core boxes would be dealt with in their categories, and the wood of which the box and the battens are to be made would be specified; here, too, attention would be paid to the proper proportioning of the parts with reference to solidity and facility of dealing with drawbacks, etc. Although the straps, lifting and rapping plates are not made by the patternmaker, their design should be carefully revised and standardised so that the price may eventually be reduced and equal or better service attained. At present patterns are in the foundry too long because the colouring of the various parts is not consistent, sometimes, indeed, it is entirely absent. It is rarely that removable parts are clearly indicated by a definite colour or by sound methods of location and fixing. A great many mistakes could be avoided by the standardisation of distinctive colours for such parts as gates, surfaces to be machined, surfaces on which removable parts are placed. Although total standardisation of patterns is impossible, a great deal can be done in the directions indicated. Even such a point as the standardisation of the terms and definitions employed in foundry practice would be a valuable aid towards the ultimate goal.

* Translated and abstracted from a Paper presented to the Fourth Paris Foundry Congress. The author teaches pattern-making at the French Foundry High School.

Making Propellers.—VIII.

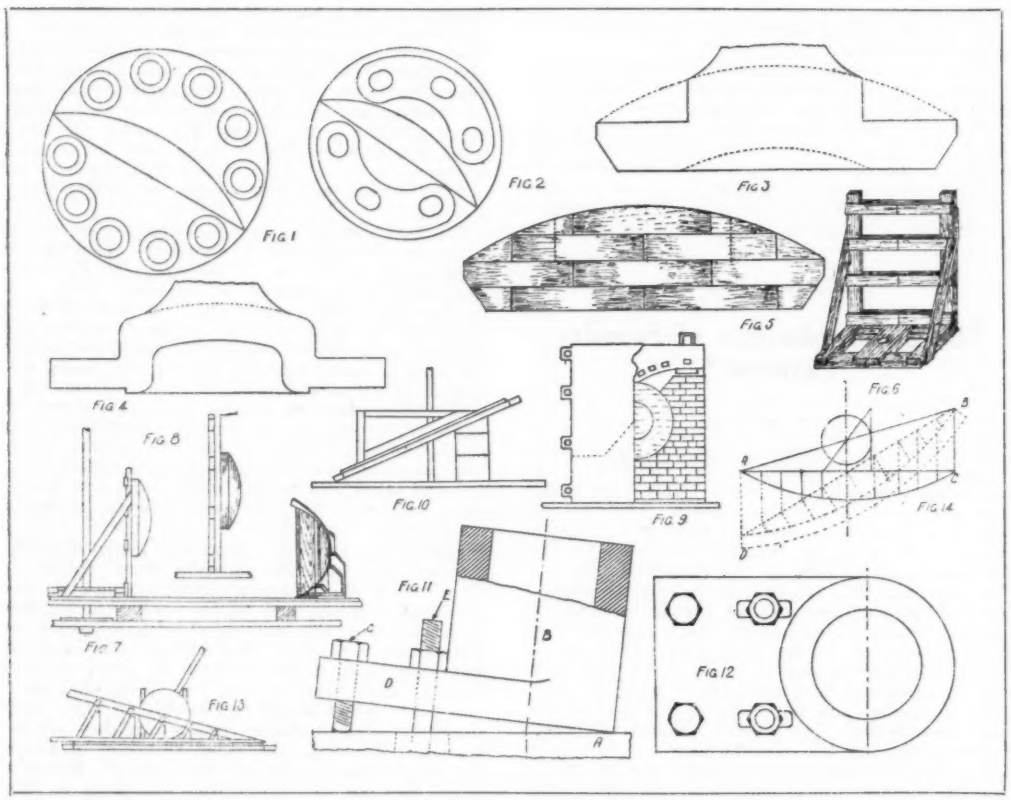
By Ben Shaw and James Edgar.

LOOSE BLADES.

In some shops, a propeller with separate blades is a very rare job; in others, there are more propellers of this kind than those with hub and blades as one casting. When a drawing for this type of propeller is received from the drawing office, the first task, as with propellers we have described in previous articles, is to set it down to full size. This, to a man who is accustomed to propeller work, does not present any special problem, but some care has to be exercised in setting off the stud holes if it is desirable that these be cast in the flanges. In some instances the flange on each blade is cast solid, the holes being machined afterwards. It is claimed for this method that the holes can be located more accurately, although it is a more costly method. When the holes are cored out, a reasonable clearance is given over the stud diameters, and they are invariably elongated so that the pitch of the blade can be modified within reasonable limits. Figs. 1 and 2 are views of two flanges of different design. Let it be clearly understood that propeller flanges, in details of design, vary considerably. At Fig. 1 is shown a flange in which the holes for the nuts are recessed separately, while at Fig. 2 there are two annular recesses for all the nuts. At Figs. 3 and 4 are shown sections of two different forms of flanges. It will be readily seen that there is practically no difference in moulding these flanges, and they are shown merely to explain the fact that there can be considerable difference between flanges without in any way affecting the general practice for their production.

When the work involves the making of blades for a twin job, in which either three or four are required for each propeller, together with spares, it is customary in many districts either to prepare a wood or a metal pattern. We have previously referred to the construction of such a wood pattern by means of a series of superimposed layers with the grain following the face of the blade from tip to flange. The great disadvantage to the use of wood for such a pattern is due to the impossibility of giving it a permanent shape. Some blades have considerable width, and, however carefully their patterns are constructed, if they are made of wood, they are liable to change their form, even when a supporting batten is secured to the face across the widest part of the blade. It is because of this weakness in a wood pattern that some firms have a metal pattern cast when a pattern is considered desirable. The metal pattern is similar to the casting taken from its mould, excepting that the flange is cast plain, and loose pieces are afterwards located for prints or facings. These are of wood. Two staples may be cast in, to project from the back of the blade, or tapped holes may be made in the pattern for convenience in lifting it. With the aid of a full pattern there is no difficulty in setting it in the foundry in such a way that the top lift is reduced to a minimum. Either a dry-sand or loam mould may be prepared, the joint following the edge of the blade. It might be mentioned here that cast-iron blades are usually cast horizontally, the runner being into the flange, while those of manganese brass are invariably cast vertically with a substantial head on the centre of the flange. The moulds are prepared horizontally, and moved to the desired position for casting.

When it is not considered desirable to make a full pattern, the surface of the blade is swept and a thickness of sand applied to it to correspond with that of the required blade. This constitutes a temporary pattern, which enables the completion of the mould in the manner previously described for a solid propeller. Before describing the preparation of such a mould, it will be as well to consider the pattern work this method involves. The sweeping boards do not differ from those described for a solid propeller, therefore a bearance board and a board for sweeping the blade surface are required. An outside angle, thickness or section pieces, a pattern for the flange, and, in order that



the flange can be maintained in its correct relationship with the angle, a bracket must be prepared to which it can be secured. In nearly all cases, flange patterns are built segmentally, and are similar to Fig. 5. The segments have to be so fixed that the nut recesses can be cut after the flange has been turned. These recesses are invariably cut from the flange instead of being cored, although we have seen them cored and the stud holes made in the same core box. In the case of a flange (Fig. 2), the annular recesses are usually cored, prints being fitted on the face of the flange.

Setting the Flange.

The bracket to which the flange is secured should be of a substantial character, as in Fig. 6. Some are made to encircle the spindle, while others are cut to fit against it, the base of the bracket resting upon the prepared bearance. A centre line should be clearly marked upon the bracket and the flange secured so that its centre line corresponds, and is at a height from the base of the bracket, which will determine its position with regard to the outer angle. When the centre line of the blade is at right-angles to the centre of the shaft, the centre of the flange will be set at the same height as the centre height of the angle, but, if the blade is "set back," then the difference between the height of the angle at the centre and the centre of the flange above the base of the bracket should correspond with the set back indicated on the drawing. Fig. 7 shows the flange lifted for a blade that is set back. This illustration indicates the more common practice of setting the flange and angle on a prepared bearance corresponding to a horizontal plane from which the blade it pitched. A board is attached to a sliding spider for sweeping the blade surface, using the angle as a runner to define the pitch. Bricks and loam are built up so that the requisite shape can be defined and a joint formed at the top and bottom of the swept surface.

The brickwork is built up to the face of the bracket, and another joint formed off the back of the flange. The setting out of the blade shape on the dried-pitch surface is carried out in a similar manner to that for a solid propeller, and has already been fully explained. When the section pieces have been located, sand is rammed between them and slicked off to form the temporary pattern, after which the cover is made. The method of carrying the cover for a loose blade varies very much. In some foundries the practice is exactly similar to that for the blades of solid propellers in which shaped bars are secured to joint plates and smaller cast- or wrought-iron bars carried through or under them; in others, however, a flat plate is bedded into the covering loam and secured to joint plates. Whichever form is adopted, it is necessary to bear in mind the manner in which the mould is to be secured to resist casting pressures.

Building the Cover.

In building up the cover, the flange joint should be prepared, and, when ready, loam is applied and a gaggered plate bedded into it, as in Figs. 8 and 9. It is customary to use a plain plate for cast-iron blades, but suitable holes are cast through those used for manganese brass blades. The plate is usually about 3 in. to 4 in. from the mould face, and a head is carried outside it through a large hole in the centre.

After one casting has been made, the amount of work in preparing the moulds, for subsequent castings of similar size and pitch, is considerably reduced, as the used mould is of a semi-permanent character and frequently only needs repairing with loam. The flange and angle should, of course, be set and the surface swept.

In making any propeller, much of the work results from the necessity—it is a necessity with propellers that are cast solid—of building a deep loam mould which is, at the lowest approximation, one-sixth of the pitch, but, with a blade that is set back, it is appreciably greater. This of necessity involves a deep lift for the cover. It is obvious, therefore, that if the blade can be canted over so as to bring the helical surface into what may be called a horizontal position, as is the usual practice when using a full pattern, much brickwork is avoided, the drag is lighter and more easily handled, the cope is more conveniently prepared, and the whole mould is more easily clamped for casting. This is a practical possibility only with single blades, although it has been adopted in very few foundries. In order to reduce the amount of brickwork, either of two methods may be adopted, one in which the bearance plate is inclined to the horizontal, and the other in which the bearance plate is maintained horizontally, but the spindle is inclined to it. For the former method, the bearance plate is prepared and the bearance dried, when it can be tilted on the bogie or foundation plate to an angle with the horizontal previously decided upon. An angle of 30 deg. can frequently be used for this purpose. It is, of course, necessary to be accurate in the setting of the plate, because the angle or race upon which the sweep rides is formed to rest upon the bearance and the working edge must define the required pitch. The bearance can be checked conveniently with the aid of a wood template, representing the angle at which the plate is to be set, as in Fig. 10, and a level.

The top surface of the template should be horizontal when the bearance is finally set. The bracket carrying the flange may rest upon the bogie plate with the face butting against the bearance plate. A centre line should be marked on the bearance from the spindle for setting both the flange and race. The position of the latter is best defined by means of a board having a nail projecting from its edge and secured to a sliding spider. The board should be set so that the nail is at that distance from the centre of the spindle for which the race has been made, say 6 in. beyond the tip of the required blade. When the blade surface has been swept and its shape defined, the use of the vertical spindle is no longer necessary, and, when the screws securing the flange have been withdrawn and the bracket removed, the bearance plate can be moved to a horizontal position for covering.

Setting Spindles at Angles.

In the second method referred to, the bearance plate remains in a horizontal direction, but the spindle, from which the pitch surface is generated, is inclined to the vertical. In principle, this method is exactly similar to that just described, as the whole is simply twisted to bring the bearance in a horizontal position, as shown in Fig. 13. There are, of course, many methods of setting the spindle at an angle to the vertical, one of which is shown in Figs. 11 and 12. In Fig. 11, A represents the building plate, B is a casting which is a sliding fit on the spindle and secured to it by set screws. Two studs C are used as jacks to raise the socket, and these tilt the spindle, and the bolts E, previously inserted, can be screwed up when the correct angle is obtained, which will hold the spindle perfectly rigid. A template and level may be used as a final check in setting the spindle.

For both these methods it is necessary to set down the shape of the race upon which the sweep rides for striking the pitch surface. Thus if B A C in Fig. 14 represents the pitch of the required blade, say 6 in. beyond the tip, a reasonable position for the setting of the race, the base of the race A C will be a true curve and form part of the circle at which the angle represnts the pitch of the blade. Supposisg the base A C is moved to an angle of 30 deg. with the horizontal and projected to D B, then B A D will represent the angle of the race. The base of the race will not be a true curve, but will be developed from where they are formed on A C, as shown in the illustration. When the bearance plate is used at an angle to the horizontal, then it will correspond to D B, and the centre line will be vertical. When the spindle is inclined, then D B will be twisted to a horizontal position, and the centre line on the race will be at the same angle to the vertical as the spindle.

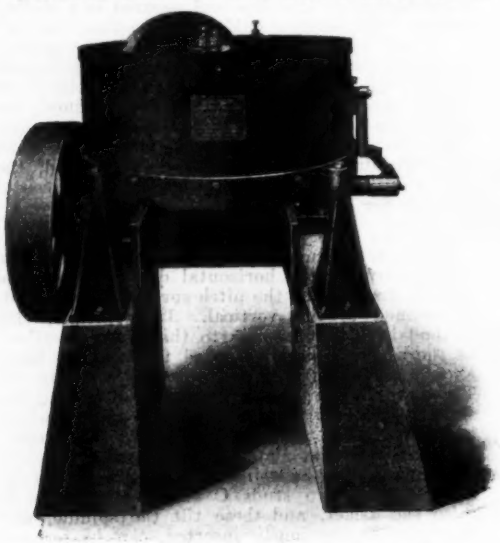
A series on propellers would not be complete that did not consider even briefly that casting which completes the propeller after it has been fitted on to the tail-end shaft, *i.e.*, the coned tail piece which is fixed over the nut. The metal is invariably about $\frac{1}{2}$ in. thick. Neither the construction of its pattern nor the making of its mould is difficult. The pattern may be built segmentally and a solid end fitted to form the apex of the cone or, alternatively, it may be built with grounds and staves. The core can best be swept vertically with a pin board revolving on a bottom plate.

XUM

The Simpson Foundry Sand Mixer.

The Simpson foundry mixer, whilst new to British foundries, has established a reputation in the United States of America. Its manufacture for Europe has been undertaken by Messrs. August's Muffle Furnaces, Limited, of Halifax, who are well-known suppliers of foundry equipment

The mixer illustrated below consists of a stationary circular pan, in the centre of which is located a vertical shaft, to which is keyed a central supporting casting or cross head, the latter resting on a turret in which are the bearings for the central shaft, the latter being operated by bevel gearing which is located below the machine and out of the way of the sand and grit. The central supporting casting carries the ploughs and mullers. Two sizes have two outside ploughs, one inside plough, and two mullers, while two smaller sizes each have one outside plough, one inside plough, and one muller. The function of the ploughs is to turn over and move the sand mixture alternately inwards and outwards, the outside ploughs moving the mass of sand inwards towards the centre and the inside ploughs moving the sand outwards towards the pan rim, while the mullers revolve on their own axes around the centre of



THE SIMPSON FOUNDRY MIXER.

the pan, the pathway of the mullers being at a point where the mixture is heaped up the highest by the movement of the plough. The action of the ploughs together with the kneading and squeezing action of the mullers result in a thorough incorporation of all the elements of the mixture regardless of its composition

A charge for the 3-ft. mixer is from 1½ to 2 cub. ft.; for the 4-ft. mixer, 3½ to 4 cub. ft.; for the 6-ft. mixer, from 7 to 10 cub. ft.; and for the 8-ft. mixer, from 17 to 22 cub. ft. of sand, which includes its quota of coal dust when facing sand is being mixed, or binder when core sand is required. Ordinarily a cubic foot of sand weighs 100 lbs. on the average. The actual time of mixing depends upon conditions, but approximately two minutes or less suffices for core sand, while in mixing facing sand either for steel or grey iron, three or four minutes may be necessary, depending on the conditions of the sand and the toughness desired. In some cases foundries are mixing facing sand in two minutes' time, while in others a longer time up to four minutes is necessary to secure the necessary results

There are a number of methods by which the capacity of the mixer can be very much increased; by the use of a bucket loader, which ensures the correct amount of any particular sand mixture being fed into the machine and increasing its capacity by reason of having a charge ready to be fed into the mixer as soon as the previous batch has been discharged. The bucket loader can be used either with the high or low setting; in the former case, the bottom of the discharge opening of the mixer is about 3 ft. from the floor line, permitting a wheelbarrow or loading car to be placed on the floor line directly under the discharge opening, while in the low setting the discharge chute is on a level with the floor line, in which case the material is discharged into a pit or into a bucket or box in a pit, the latter to be picked up by a crane or hoist and taken to the core room if core sand is being mixed, or to the foundry floors if facing sand is being prepared. The mixer, of course, can be fed by a shovel or from overhead hoppers, or in any other manner that may be deemed advisable, according to conditions existing in any particular foundry.

One of the most advantageous points about the operation of the mixer is the method of discharging a batch of sand. It is accomplished by having a door situated in the bottom of the pan, which is opened by the action of a lever on the side of the machine. It is necessary simply to trip this lever, which opens the door, and the same ploughs that turn the material over upon itself and under the mullers discharge the contents automatically through a chute shown in the illustration. This is an exceedingly important point, and not only increases the capacity of the mixer, but also eliminates any labour necessary to discharge the material after the mixing has been completed.

The question of saving labour is a very important one. The intensive foundry mixer has proved in many foundries its ability to produce the necessary results with a minimum of labour. The concentration of sand-mixing operations will effect in some cases a saving in labour costs sufficient to pay for the mixer within a short time.

The mixer requires only about one-fourth to one-sixth the horsepower to operate it compared with the power required for the old type of pan mill. In foundries where the mixer has been installed where formerly the old type of pan mill was used the saving in power has been very marked and has resulted in a very considerable saving over a short period of time. Also, the mixer is built very substantially and is of rugged construction so as to stand up under hard and continued service. Its maintenance cost, therefore, is exceedingly low not only by reason of the saving in power, but also because of the minimum repairs required.

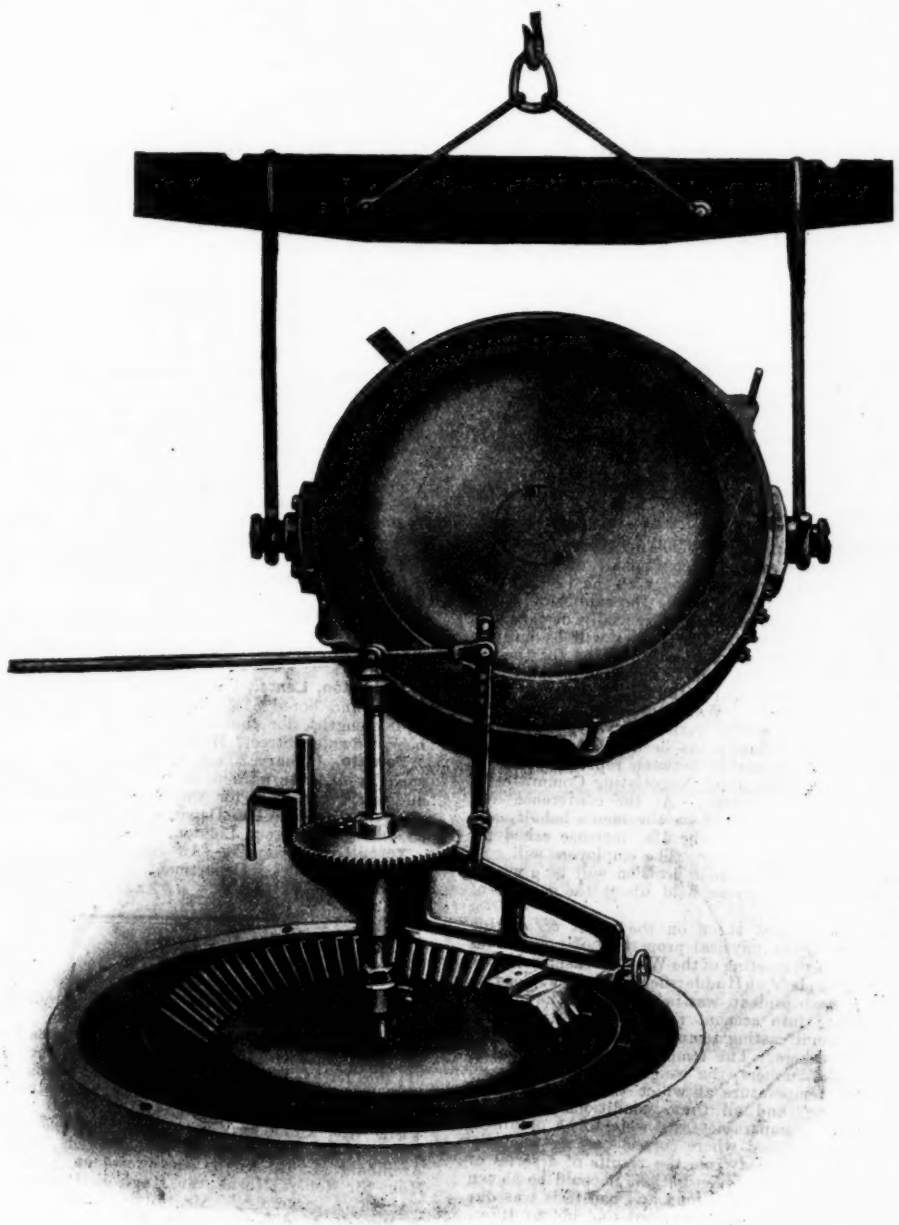
The efficiency of any new material entering a mixture depends practically entirely upon the effectiveness of the mixing unit, regardless of whether the new material be new sand, clay, dry or wet binders. That the muller type of mixture as exemplified in the intensive foundry mixer is best suited for this work has long been conceded The greater efficiency of the intensive foundry mixer as compared to the mixer of the pugmill, or to those other types of pan mixers not especially designed for sand mixing, is due to the squeezing and kneading action obtained by the mullers together with the constant turning over of the sand by the proper arrangement of the ploughs. The mixture in this manner is changed from a friable and a loose condition to a strong, tough and plastic mass.

Pan mills of the old-fashioned type are provided with excessively heavy mullers that tend to break the grains of the sand. This objection has been entirely eliminated in the design of the intensive foundry mixer by reason of correct design and adjustability of muller with just sufficient weight and width of face to mull and knead the sand properly so as to produce the necessary plasticity and toughness without breaking the grain of the sand. Therefore, the original porosity of the sand mixture is not destroyed and the "openness" of the mixture is maintained.

AN AMALGAMATION has been arranged between Minerals & Metals, Limited, of 4 Lloyds Avenue, London, E.C.3, and Maule, Hunter & Company, Limited, of 11, Waterloo Place, London, S.W., whereby the business of the latter has been acquired by the former company. Major W. P. Maule and Mr. J. Hunter, directors of Maule, Hunter & Company, Limited, have joined the board of directors of Minerals & Metals, Limited. The business carried on by the above companies will continue as before, but it will be carried on solely by Minerals & Metals, Limited, who have transferred their offices to 1, Queen Anne's Gate, London, S.W.1.

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.



THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

JAMES EVANS & CO., BRITANNIA WORKS, (MANCHESTER), LIMITED,

BLACKFRIARS, MANCHESTER.

Trade Talk.

A FIRE BROKE OUT at the spring-hardening shop of John Tonks & Company, Hallcar Works, Rutland Road, Sheffield, on November 21, but the damage was fortunately small.

MR. F. E. THOMPSON presided at a lecture to the members of the Walsall Engineering Society last week, when Mr. A. Constable, of Guest, Keen and Nettlefolds, Limited, dealt with the question of "The Use of Fuel Oil in Furnaces."

A SYDNEY (N.S.W.) cable states that the Sutherland Council has accepted the tender of Sir W. G. Armstrong, Whitworth & Company, Limited, of £80,320, to provide steelwork for the proposed bridge over the George River at Tom Ugly's Point.

THE ZENICA COMPANY in Bosnia have been obliged to stop work at their steelworks on account of the keen competition of the works in Germany, who offer steel products at a price at least 10 per cent. below the costs of production of the Yugoslav works.

MR. A. MARKS, of Dudley, gave a discourse on "Non-ferrous Metals in the Foundry and Engine Works," on November 21, before a joint meeting of Sheffield technical societies at the Sheffield Metallurgical Association's rooms, West Street. Professor Desch presided.

THE OUTPUT of engines at the works of Petters, Limited, Yeovil, in September, broke all previous records in the history of the firm. As a matter of fact, the money value of the orders was exceeded in two or three months in 1920, but the price per horsepower then was very much higher than it now is, so that the volume was considerably greater in September last.

THE HIGH COMMISSIONER FOR THE UNION OF SOUTH AFRICA has placed an order on behalf of the South African Railways Administration with the Leeds Forge Company, Limited, of Leeds, for the supply of a pair of coach underframes and bogies specially designed on the articulated principle. The bodies will be built in South Africa. These coaches are intended for the use of the Governor-General, and in the first instance will be employed in connection with the forthcoming visit of H.R.H. the Prince of Wales to South Africa.

A STRIKE IN CONNECTION WITH THE WAGES DISPUTE in the light castings industry has been avoided meantime as a result of a conference between representatives of the employers and the Joint Negotiating Committee of the twelve unions involved. At the conference new proposals were put forward on the men's behalf, and these were, in effect, that the 15s. increase asked for should be granted by stages. The employers will consider this proposal, and their decision will be given at a further conference to be held about the middle of December.

A DISCUSSION TOOK PLACE on the effect of casting temperatures on the physical properties of non-ferrous alloys, at a recent meeting of the West Yorkshire Metallurgical Society, held at Huddersfield. Mr. H. F. Coggon, of Halifax, the president, was in the chair. The importance of taking into account foundry conditions when defining optimum casting temperatures was emphasised by several speakers. The temperature of the moulds, the size of the runners, the weight of the casting all influence the temperature at which the metal actually fills the casting, and all these conditions should be standardised if comparable tests were to be obtained. Examples were quoted where correct casting temperatures had been specified from the results of a series of tests when, on further investigation, it could be shown that the difference between good and bad tests was due to differences in the sizes of runners and not to differences in the casting temperature. When the casting temperature was too high or too low the resultant metal would be porous, of low density and low hardness. The formation of blowholes would also often be due to low casting temperature. Generally speaking, the defects due to low casting temperature were of a physical nature, whereas a high casting temperature brought in chemical defects.

Obituary.

MR. J. STUART, of Warren & Stuart, consulting engineers, Glasgow, died recently, aged 73.

MR. J. WILLIAMS, iron and metal merchant, Blackpool Street, Burton-on-Trent, has died at the age of 48 as the result of an accident.

MR. R. POLLOK, formerly shipyard manager at Barrow to Vickers, Limited, retiring in 1921, died recently. For many years he was shipyard manager of John Brown & Company, Limited, at Clydebank.

MR. J. S. MORRISON, the well-known civil and mechanical engineer, died recently in London. About 5 years ago he became engineer to the Cyprus Mines Corporation, and erected the company's ore landing pier at Cyprus.

Contracts Open.

Alicante, December 30.—Portable bridge crane. The Ilustrisimo Señor Director de la Junta del Obras del Puerto, Alicante.

Blackpool, December 8.—41½ tons of mild-steel bolts, nuts and washers, for the Fylde Water Board. Mr. G. F. Atkinson, engineer, Head Office, Sefton Street, Blackpool.

Cairo, December 22.—Supply and erection of two crude oil engines, two air compressors and auxiliary machinery, required by Power Station Machinery, Tanta Main Drainage Scheme. The Adjudication and Purchases Board, P.W.M., Cairo.

Corunna, January 20.—20-ton electric crane. The Ilustrisimo Señor Presidente de la Junta del Obras del Puerto, Coruña (Corunna).

Dublin, December 11.—13½ tons of flat-bottomed steel rails, complete with fishplates, for the Dublin Port and Docks Board. The Engineer's Office, East Wall, Dublin.

Dublin, December 12.—Bull-head rails, flat-bottom rails, and fishplates (of British standard sections), also cast-iron chairs, for the Great Northern Railway (Ireland) Company. Mr. J. B. Stephens, secretary, Amiens Street Station, Dublin.

Hayfield and Mellor, Derbyshire, December 15.—Providing and laying about 7½ miles of 6-in., 5-in., 4-in. and 3-in. cast-iron pipes, with all necessary valves, hydrants and apparatus, for the Hayfield R.D.C. The office of the Surveyor, Hayfield, Derbyshire, or at the offices of the engineers, Messrs. G. & F. W. Hodson, Bank Chambers, Loughborough. (Fee, £5 5s., returnable.)

Johannesburg, January 3.—One, or alternatively two, 10-ton overhead hand-travelling cranes, for the Municipal Council of Johannesburg. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1.

London, W., December 8.—Iron and steel, from January 1 to June 30, 1925, for the Great Western Railway Company. The Stores Superintendent at Swindon.

Middleton, Lancs., December 9.—1,320 yards of 6-in. turned and bored cast-iron socket and spigot pipes in 12-ft. lengths, for the Town Council. The Gas Engineer, Townley Street, Middleton, Lancs.

Toronto, January 20.—Centrifugal sludge pump of a capacity of three million imperial gallons per 24 hours and electric motor, for the City of Toronto Department of Works. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1.

Toronto, January 20.—Air compressor, for the City of Toronto Works Department. The Department of Overseas Trade.

Personal.

SIR ALFRED M. PALMER has been re-elected chairman of the Tyne Improvement Commission.

THE RIGHT HON. SIR AUCKLAND C. GEDDES has been elected a director of the Rio Tinto Company in place of the Right Hon. Sir Arthur Steel-Maitland, Bt., M.P., who has resigned on being appointed to the Cabinet.

SIR WM. CHARLES WRIGHT has been elected president of Baldwins (Montreal), Limited, with Mr. Archibald M. Russell as vice-president, and the Rt. Hon. Sir Robert Horne, Sir Hugh E. Poynter, Bart., Mr. D. A. Campbell, Mr. Blair Russell, and Mr. J. Russell as directors. Sir Wm. C. Wright is at present in Montreal.

MR. W. LOW, chairman of directors of James F. Low & Company, Limited, Monifieth Foundry, and his son, Mr. H. J. Low, have severed their connection with the firm. In the new board which has been constituted, Mr. C. T. Gordon will continue in the position of managing director. It is pointed out that the foundry remains an entirely independent concern.

Wills.

WALLACE, R. T., of the Brookfield Engineering Company	£12,392
COOK, J., of Wallington, Surrey, for 46 years secretary of P. & W. MacLellan, Limited	£13,256
SKINNER, H., of Ranskill, Notts, senior partner in the firm of Skinner & Johnson, engineers, Ranskill	£12,126
JONES, W., of Stourbridge, Worcs., formerly chairman and joint managing director of Jones & Attwood, Ltd., Stourbridge	£39,793
RUCKER, R. W., joint managing director of the British Metal Corporation, Limited, a director of P. R. Muntz & Company, Limited, and of Henry Rogers Sons & Company, Limited, a former chairman of the Committee of the London Metal Exchange	£5,937

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Business in the Cleveland iron market, as is a customary experience towards the close of the year, has been on a rather more restricted scale than during the past few weeks, but the tone continues steady, with a firm undercurrent of increasing confidence in future outlook for the industry. Home consumption especially evidences an increasing tendency, but on the export side this development has been checked, Continental prices having fallen away again below a competitive basis on this market. Prices meantime continue firm at last week's levels, with No. 1 quoted 86s. to 87s. per ton, No. 3 G.M.B. 82s., No. 4 foundry 81s., and No. 4 forge 80s. per ton respectively.

In the Tees-side market for hematite conditions continue steady, demand in the home consuming centres being more active, while business with the Continent shows a small but welcome increase. The recent American inquiry does not appear to have come to anything. Prices are unchanged, East Coast mixed numbers having been done at 88s. 6d. per ton, with 6d. per ton more for the No. 1 quality. In West Coast area prices are also unchanged, though the tendency is for them to harden, Bessemer mixed numbers being quoted at 100s. per ton delivered at Glasgow, 102s. 6d. per ton delivered at Sheffield, and 110s. per ton delivered at Birmingham.

LANCASHIRE.—Buying in the local markets for foundry iron remains limited in volume, with prices practically unchanged, the quotation for No. 3 Derbyshire foundry pig-iron now ruling at 90s. per ton delivered Manchester, based on 82s. 6d. per ton at the nearest furnaces. Reports of lower prices accepted at some of the Derbyshire furnaces still come to hand, but that may be because the rate of carriage to Manchester is a little more. It may perhaps be doubted whether it is now possible to buy any No. 3 Derbyshire iron at less than 90s., delivered here.

THE MIDLANDS.—At the Birmingham market last week business was fairly active, with an encouraging volume of orders in circulation for foundry quality pig. Prices continue firm, as follow:—Derbyshire No. 3 foundry, 82s. 6d.; Staffordshire No. 3 foundry, 85s.; Northants No. 3 foundry, 76s.

SCOTLAND.—Some improvement may be noted in the local markets for foundry pig, makers reporting an increase in the number of inquiries, although prices remain unchanged, with No. 3 quality still at 90s. per ton at the furnaces.

Finished Iron.

There is little improvement, if any, in this section of the market. Certain mills report that inquiry is distinctly better, and they are hopeful that business will develop. On the other hand, others remain sceptical, and state that while the present foreign quotations obtain business cannot improve; of course, this latter position applies almost entirely to iron of the cheaper grades, as the marked bar makers do not experience any foreign competition, and, at present, find no difficulty in obtaining their figure of £15, f.o.t. works. The mills engaged in the manufacture of crown and nut and bolt iron have to bear the brunt of the Belgian and French competition, which has been, and still is, very severe. This state of affairs has already had its effect in the district where several works are closed down, and in some instances will never resume.

Steel.

At Sheffield business in semi-products has been on a slower scale, with prices, however, fairly steady. Against this slowness in the market is the report of better times in the steel trade, indicating that manufacturers are working on supplies in stock. A number of open-hearth furnaces are being put into operation again, which is a cheering sign. Both the heavy and lighter steel branches are better employed. Some fairly substantial orders from India and the Colonies are being placed, chiefly for railway steel. Makers of axles, wheels and tyres are getting busier, while the demand for agricultural, garden and edge tools is now on a considerable scale, while builders' iron and steel work is a valuable feature.

Scrap.

After a long period of depression it is encouraging to note a slight trace of improvement in demand for scrap metal, but this, so far, is mostly confined to steel material. For foundry purposes, Lancashire dealers are inclined to be a little stiffer in their prices, but good scrap can still be bought at 80s. per ton. If there be any truth in the reports that an early revival in the demand for textile machinery is anticipated, then it might be well for the iron-founders to secure a stock of fine scrap, such as broken machinery iron, and this could be bought now at 85s. per ton. In Scotland there is no change in machinery cast-iron scrap at 90s. per ton, with second quality 5s. per ton less. Old cast-iron chairs are 85s. to 87s. 6d. per ton. Light cast-iron scrap is still 72s. 6d., and if mixed with firebars about 2s. 6d. per ton less.

Metals.

Copper.—Values in the market for standard copper continue fairly steady, the occasional fluctuations experienced being mainly due to the statistical position mostly an unknown quantity to the majority of operators on this side of the Atlantic. Although the outlook has been viewed with rather more confidence of late, the warrant market has proved very disappointing to bull operators, despite the improved position in the United States. Current quotations :—*Cash*: Thursday, £63 15s.; Friday, £63 17s. 6d.; Monday, £64 5s.; Tuesday, £64 5s.; Wednesday, £64 5s.

Three Months: Thursday, £64 17s. 6d.; Friday, £65; Monday, £65 7s. 6d.; Tuesday, £65 7s. 6d.; Wednesday, £65 5s.

Tin.—Despite apparent irregularities in quotations, there appears to be an under-current of increasing strength in operators' ideas of the position in standard tin. An eventual further development of the bull movement depends on a more vigorous demand for near tin, the rather heavy discount on which has excited some little adverse comment lately, since there has been a further reduction in the quantities held in home ports. Immediate market prospects are rather uncertain, partly on account of the much freer movement of Straits supplies in the current month, this being placed at about 6,500 tons. Current quotations :—*Cash*: Thursday, £258 7s. 6d.; Friday, £258 15s.; Monday, £261; Tuesday, £260 10s.; Wednesday, £259 5s.

Three Months: Thursday, £261; Friday, £261 5s.; Monday, £263 10s.; Tuesday, £263 5s.; Wednesday, £262.

Spelter.—Conditions in this section of the market remain practically unchanged, with perhaps a little freer buying on galvanisers' account. Demand on the part of consumers continues moderately good, and the Continental conditions continue firm. There is rather a notable scarcity of Belgian zinc, but every confidence is expressed that the American supply can meet all requirements. Current quotations :—*Ordinary*: Thursday, £35 11s. 3d.; Friday, £35 15s.; Monday, £35 18s. 9d.; Tuesday, £35 18s. 9d.; Wednesday, £35 11s. 3d.

Lead.—The market for soft foreign pig has been subject of late to some sharp fluctuations in values, due mostly to realisations on speculative account, but the general disposition is to look for a further advance in the near future. An increase in building activity will probably cause a further rise in the near future, however, as it will take some time to increase production materially. Current quotations :—*Soft foreign (prompt)*: Thursday, £41; Friday, £41; Monday, £40 15s.; Tuesday, £41; Wednesday, £39 12s. 6d.

The Refractories Association.

The Refractories Association, which has for its members most of the important producers of refractory materials of the country, held a most successful evening meeting at the Royal Victoria Hotel, Sheffield, on Thursday, November 27, there being present 25 members from various parts of the country. The chair was taken by Mr. Job Holland, of Pickford, Holland & Company, Limited, Sheffield, and amongst others present were the president, Mr. Frank Russell, of the General Refractories Company, Limited, Sheffield; the president-elect for 1925, Mr. Frank J. Boam, of Joseph Boam, Limited, Leicester and King's Lynn; and the secretary, Mr. W. J. Rees, of Sheffield University.

The president, Mr. Frank Russell, gave a most interesting address on "Sands: Their Occurrence and Uses," and, whilst introducing to the members uses for sands of various descriptions which were not commonly known, devoted the most of his attention to sands for furnace and foundry uses, for glass-making and for the brick and allied trades. He was, with his wide knowledge of the subject, able to dispel certain popular fallacies in regard to types of sand most suitable for various classes of work, and to put before the members many sound and practical theories and suggestions. The address was given in a most attractive manner, and the meeting closed with a vote of thanks, proposed by the chairman and seconded by Mr. W. J. Rees, who gave supporting information and facts.